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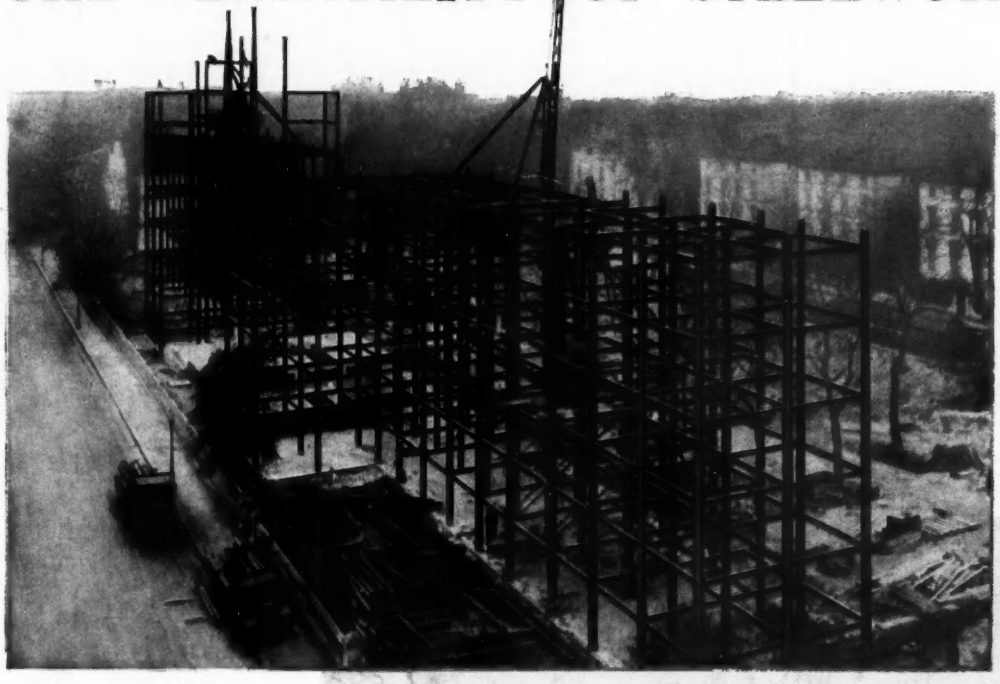
THE VERSATILITY OF STEELWORK



The frame-work for a London block of flats.

Familiar sights

The steel framework of multi-storey buildings, and the steelwork of bridges, is a familiar sight that is taken for granted. Yet nowhere are the advantages of steelwork more evident: all members are pre-fabricated in specialized workshops, erected by positive and straightforward means, moreover the steelwork is going through the shops while the foundations are being prepared.

These are the advantages, cumulative in their economic result, which have established steelwork as the outstanding structural medium of the world.

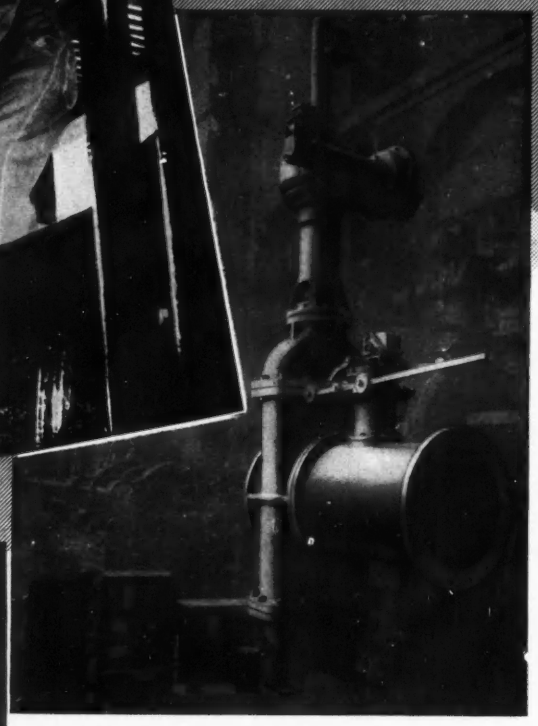
STEEL STRENGTH SECURITY

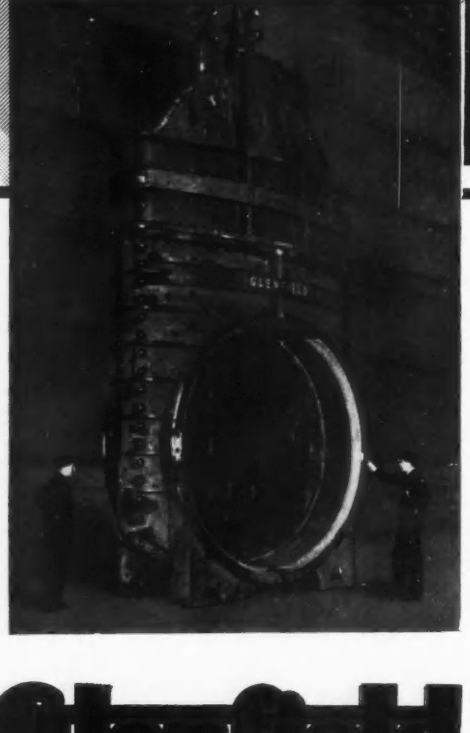
B·C·S·A

A heavy steel bridge span.

BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION, ARTILLERY HOUSE, WESTMINSTER, S.W.1.

ELECTRICALLY OPERATED SLUICE VALVES





The electrical operation of large sluice valves and even of smaller valves working against considerable unbalanced pressures not only precludes the arduous efforts required for manual operation, and increases the speed of operation but provides distinct advantages in its adaptability to automatic and remote control in ways suited to many different circumstances.

Glenfield electrically-operated sluice valves are available in all sizes, in both inside and outside screw types. Standard types are robustly constructed of Meehanite metal with four gunmetal valve-faces, two on the body and two on the door, adjusted to a perfect droptight bearing. The spindle is of the finest solid forged bronze and works in a spindle nut of gunmetal, screwed square thread.

Special valves are available in bronze, steel or corrosion-resisting alloys.

The motor is designed to develop a high starting torque and the power is transmitted to the spindle through machine cut spur and worm reduction gear in a totally enclosed oil bath. Limit switches are fitted which automatically cut off the power at the extremes of valve travel and the Glenfield patent safety electrical interlock automatically prevents the power operation of the valve while the crank handle is in position. These valves can be supplied with distant control and gate-position indicators if desired.

The illustration shows three examples of our electrically-operated valves, (top) by courtesy of Messrs. Dahl Bros., Copenhagen, a 1,000 mm. (39½in.) valve supplied to Copenhagen Waterworks, (centre) a 25in. automatic self-closing "follower-ring" type sluice valve and (bottom) one of several 9ft. diam. valves supplied for a recently completed graving dock.

Glenfield

GLENFIELD & KENNEDY, LIMITED, KILMARNOCK

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Productivity in British Industry*

No. XIII—THE MEASUREMENT OF PRODUCTIVITY

By L. H. C. TIPPETT†

THE word productivity is usually taken to mean labour productivity, and this usage will be adopted for this article. The productivity of the machines and capital equipment of a factory is often as important as that of labour: sometimes it is all-important; and the productivity of other factors such as raw materials and energy deserves due consideration. All these, together with good design and other elements of good management, are the constituents of low cost, which is one of the main objectives of industrial enterprise. But cost is a complex thing and it is in accordance with the scientific method to break up the complex into its parts and study them separately. One factory may be producing at a higher cost than another but until the difference is analysed little or no action can be taken.

Of the factors affecting cost, labour productivity is both convenient and important to study. It is convenient because one of the basic units, the man-hour or man-year, is fairly stable and concrete. For example, the difficulty of allowing for different degrees of skill associated with different types of man-hour are negligible compared with those of allowing for rates of exchange and cost of living when making international comparisons in terms of money units. Labour productivity is important because very many things that increase it also reduce the cost of manufacture. But because some actions that increase productivity do so at the expense of increased costs or reduced quality, conclusions reached from productivity studies alone may sometimes require qualification; that, however, does not destroy the value of the studies.

Productivity statistics are utilised in many ways. Political economists, who speculate upon and plan the economic future of the country, need to know the trends in productivity for the whole of industry: the Economic Survey for 1950 could not have been written without some assumption about the productivity for 1950. Unfortunately, differences that are important in such studies are sometimes little greater than the errors with which they are estimated and the annual increase in the overall productivity of the country cannot be estimated with any great precision. Broad comparisons have been made between corresponding British and American industries, but they have done little more than establish the existence of the much higher labour productivity in the U.S.A. Some economists are interested in using measurements of productivity to investigate empirically the influence of general factors such as the size of the firm, the standardisation of products, and the degree of mechanisation of processes; but some people with an engineering and industrial background are apt to be sceptical of this approach.

Measurements of productivity for individual manufacturing concerns are sometimes used by top management and other interested parties as evidence of good performance. Thus, Lord Hurcomb has recently presented to the Manchester Statistical Society, among other figures, the ton-miles of railway freight per engine-hour and has suggested that an increase of 18 per cent from 1938 to 1948 is evidence of "substantial improvements in working." As Lord Hurcomb points out, however, such statistics need to be interpreted with care, and one hears little now of a recently-canvassed idea that productivity or some similar index could be used as the criterion of the effectiveness of the management of nationalised undertakings, when account is rendered to Parliament and the public. Nevertheless productivity statistics for individual concerns have some value in this kind of way, provided they are not acted upon without supporting information. Where improvements have taken place, the measure of productivity will usually show this, and a fall in the productivity value quite justly calls for investigation. Productivity statistics also have a good psychological effect. Provided the rewards and penalties based upon them are not too drastic, they act as a stimulus to improved management and effort, and they foster "productivity consciousness." This effect is not to be derided, for the common refrain of all the productivity reports written by the industrial teams sent to the U.S.A. under the ægis of the Anglo-American Council on Productivity is the important effect of the attitude to productivity of all engaged in American industry.

Most fruitful of all are the uses of productivity measurements made by the operating managements of factories (i.e., by works and departmental managers and foremen) in striving after excellence. Productivity in some departments may be measured shift by shift and the causes of variation investigated, so that causes of low productivity are eliminated and all the operating personnel are stimulated to effort. Or a factory may have a programme for improved productivity and it may use (say) monthly figures for separate departments or products in order to measure progress. Some new manufacturing method or administrative procedure may be installed, and the effect on the measure of productivity will be one criterion of success. Factories working similar processes or making similar products may compare productivities so that the management of those with low values will learn of this and will have some guidance as to the possibilities of improvement. Similarly, comparisons may sometimes be made between departments in a factory or even (where they work more or less independently) between individual operatives. Activities of these kinds are going on in British industry, as is shown in a pamphlet which the Anglo-American Council on Productivity has in preparation and expects shortly to publish. The chief common characteristic of these activities is that the figures are given in detail, they cover a narrow field and they are presented clearly and quickly, so that the managers, foremen and operatives who are in a position to improve matters can use the figures as a basis for action. There can be no doubt that the more localised are productivity studies and the greater is the engineering information accompanying them, the clearer are the conclusions and the greater is the chance of effective action ensuing.

Details of Measurement

Productivity is usually measured as the output of the production unit (factory, industry, &c.) for a given period divided by the labour time (man-hours, man-years, &c.) engaged in that production during that period. The reciprocal of this, the man-hours per unit of production, is, however, a useful measure to use when several processes, departments or types of labour contribute to the same products; for then the total man-hours can be analysed into its component parts.

Several decisions have to be made when setting up a measure of productivity. One is the size of production unit to be covered: whether an individual operative, a department, a factory, an industry, or even a country. Broadly, the smaller the unit the easier it is to define productivity and interpret the results, but the decision will depend on the purpose of the investigation. The length of the given period over which productivity is measured and the frequency of the measurements will depend partly on the purpose of the investigation and partly on the nature of the process. Economic studies and inter-factory comparisons may be made only very occasionally; perhaps once and for all, or at intervals of years; and the "given period" will be fairly long so as to average out the effect of short-term fluctuations and to make negligible the effect of fluctuations in work in progress. If time fluctuations for a factory are being studied, the top management may be content to have, say, quarterly figures; but the operating management will need more frequent figures—say, reports given shift by shift, week by week, or month by month, according as the process is susceptible to short or long-term fluctuations. Generally the closer the user of the statistics is to the operating level, the more frequently will he require fresh information.

The labour time to be included in the measure must be carefully defined, and the question of including ancillary workers, administrative and supervisory staff must be examined. The labour employed in certain departments alone may be included (e.g., assembly departments), or that employed in all departments (including, say, departments that make components). Allowances may need to be made for trainees who contribute something to production, but less than a fully trained operative. These considerations must be borne in mind when making inter-factory comparisons, for one factory may be administered entirely on the spot, whereas another may be administered from head office; one may do all its own maintenance and another may employ outside firms for this; one may make all its own components and another may buy some; one may have a larger proportion of inexperienced operatives than another. Further, the man-hours included may be those actively expended, those paid for by the management, or those paid for plus absentee hours; and the decision on which are to be counted again depends upon the purpose of the study. If the effectiveness of the labour force is under investigation it would be misleading to include the man-hours spent inactive because of, say, machine breakdowns; but

* No. I, "An Introductory Survey," by B. White, appeared February 17th; No. II, "The Threshold of Productivity," by F. A. Martin, March 3rd; No. III, "High Productivity and Production Costs," by Sir Claude Gibb and Gordon M. Baker, March 17th; No. IV, "Standardisation in the Aircraft Industry," by E. C. Bowyer, March 31st; No. V, "Restrictive Practices," by Arthur Woodburn, April 21st; No. VI, "Research for Productivity," by Dr. D. F. Galloway, May 19th; No. VII, "Consequences of Simplification," by W. D. King and H. Sherburn, June 30th; No. VIII, "Works Extensions," by C. K. F. Hague, July 28th and August 4th; No. IX, "Mechanical Handling," by F. Garner and A. Siddall, August 11th and 18th; No. X, "The Importance of the Craftsman," by F. V. Everard, September 1st; No. XI, "Productivity in the Smaller Engineering Works," by Antony Vickers, September 15th; No. XII, "Productivity in Civil Engineering," by Lieut.-Colonel C. M. Norrie.

† British Cotton Industry Research Association and Consultant to the Anglo-American Council on Productivity.

if the effectiveness of the whole department—workers and management—is to be measured, this inactive time must be included. When assessing the productivity of the coal mining industry as a whole with the national economy in mind it is usual to include absentee man-hours, which is another way of saying that the man-year rather than the man-hour is then the appropriate unit of time.

Measurement of Output

After the decision has been taken of what labour to include in the reckoning there may arise practical or accountancy difficulties of obtaining the data, especially of allocating the labour contributed by the common services of a factory when only a part of the output is under investigation. The chief difficulties, however, are in defining the output. Even in the simplest situations, when the output is a common product such as coal, or matches, the effect of quality cannot be ignored. Sometimes the effect can be measured: for example, it is theoretically possible to substitute in the statistics of coal output British thermal units for tons, although whether the increased cost of obtaining such data would be justified by their increased value is a matter for consideration. But for most industrial products there are many aspects of quality that we have not yet learnt to evaluate. For example, I do not know of any objective way of expressing the value of a hand-made article of exclusive pattern relative to that of a mass-produced article of the same kind. Usually it is presumed that the systems of inspection and control of quality are adequate and that only satisfactory products are passed out of the factory and counted in the production. Any differences in quality that escape this control are roughly allowed for when interpreting the statistics, just as we express our view of the deterioration of the quality of coal since before the war by grumbling when the output in tons is quoted.

Most industrial products, however, also vary in their specification within the same general description, even when produced by the same factory. For example, one specification of a textile fabric may require two or three times as much labour per yard to produce as another, and mills may produce many different types in proportions that vary from mill to mill and from time to time; output in yards is too crude a measure for studying labour productivity in weaving except in the very limited field in which there is standardisation and segregation of type. Likewise a steel rolling mill may make a considerable variety of billets or rods and a light engineering works may make a variety of products. The problem is to reduce products over a sufficient range to a common measure so that useful comparisons can be made.

Something can often be done by choosing a suitable measure of output. In cotton spinning, for example, the productivity of doffers could be measured by either the pounds of yarn handled per man-hour or the number of bobbins of yarn handled per man-hour. Since it takes approximately the same time to handle a small bobbin as a large one, the second of these measures is substantially independent of bobbin size, and it is suitable for comparing productivities of operatives doffing bobbins of different sizes. From the point of view of the cost of doffing per pound of yarn, the reciprocal of the pounds handled per man-hour is the significant measure; but

$$\text{pounds per man-hour} = \frac{\text{bobbins per man-hour}}{\text{bobbins per pound}}$$

and when considering operating efficiency it is better to study separately the two components on the right-hand side of the equation, even if cost is the ultimate interest.

A measure of output that is sometimes used is the net value of the products: the money value at, say, market prices minus the value of the raw materials used. This is attractive because the data are fairly readily obtainable, and the measure can, in principle, cover a very wide range of products. In some circumstances it may be the only measure available, but it should be used with great caution and interpreted with great care. Market prices are subject to powerful influences of which technical value is only one; it is obviously inappropriate to use as a measure of value the cost price, for such a procedure would lead to the false conclusion that the most inefficient firms with the highest costs have the highest productivity. The net value as a measure of output needs to be investigated by comparing its results with those given by other measures.

Usefulness of Time Study

Where time study is adopted the "standard time" required to produce an article may be used as a measure of the "labour content" of that article, and that time multiplied by the number of articles produced is a measure of output that is common to a wide range of products. The standard time is, of course, the time a standard operative, putting forth a standard amount of effort, would be occupied in making the article, and actual operatives may, on the average, take more or less than this, so that the production per man-hour expressed in this way may be more or less than one standard hour.

This method is easily applied to the measurement of the productivity of direct labour over a very wide field; there may be a little more difficulty in dealing with the standard time for such indirect labour and services as may need to be included. The method depends for its validity on the standardisation of time study procedures so that different time study engineers, observing the making of the same products, perhaps under different local conditions, arrive at the same standard time, and observing the making of different products, arrive at standard times that correctly represent the relative labour contents. It is not surprising that the Joint Committee of the Institution of Production Engineers and the Institute of Cost and Works Accountants set up to study productivity measurement were early led to investigate time study (see their report, "Measurement of Productivity," December, 1949).

For comparing labour processes of the same general kind, such as the different metal machining processes, or types of component assembly, or groups of textile processes, we may expect the method to be successful. Only the relative times of the processes under comparison really matter, and care alone suffices to obtain these with sufficient accuracy when the processes are not dissimilar. But for comparing markedly dissimilar processes such as metal machining with cotton spinning, or component assembly with the operations of steel rolling, the method does not look so promising. There is a substantial subjective element in the assessments of time study; this can be standardised for work of the same general kind, but it is doubtful if this is possible for comparing totally different types of work.

The standardisation of time study for the purpose of measuring productivity includes measurement on the basis of some standard manufacturing method. If two factories making the same article employ different methods of manufacture so that the standard time for factory A using its methods is greater than the standard time for factory B using its methods, and if these standard times are used in the way described above to compare productivities, factory A will appear to have the higher productivity, even though it produces only as many articles per man-hour as factory B. The same standard time based on the same manufacturing methods must be used throughout. Which particular methods shall be used as a basis of measurement is usually a matter of arbitrary, but relatively unimportant, choice.

The use of the same standard time in the measure of productivity for factories A and B gives an overall comparison of the effectiveness of the production engineers, operating management (including foremen) and operatives. But sometimes the methods of manufacture may be taken as given and it may be desired to compare the operating productivities. This may be done by comparing the ratio,

$$\frac{\text{standard time per article}}{\text{actual time per article}}$$

the standard in the ratio being different for the factories, and the actual time being an average for each factory calculated from the output over a given period and the man-hours involved.

Sometimes the labour content of different products can be determined empirically from the study of past records. Mr. A. W. Swan, in a paper on Operational Research, recently published by the Manchester Joint Research Council, describes how, in order to measure output, the different steel billets and rails made at a works were grouped into a few broad classes and the average rolling time per ton was determined for each class from past records. The relative values of these times were expressed as factors, the lowest being 1·0 and the others extending up to 1·6. Subsequently, the output of the shift was measured as the sum for all classes of rails and billets of the tons of each class produced multiplied by its factor—i.e., as the equivalent tons of the 1·0 class.

Mr. D. C. Shaw describes in an article in the Manchester School (Vol. XVIII, 1950, page 14) how he took account of changes in the "count" of cotton yarn (count is the inverse of the weight per unit length) when comparing the productivity of spinning mills in 1939 and 1947. For a number of mills spinning different counts in 1939, he plotted O.H.P. (operative-hours per 100 lb of yarn) against count and empirically fitted a straight line from which could be determined for any count the labour content in operative-hours per 100 lb. Then the unit of productivity for making comparisons was not the weight of yarn produced per unit time, which would be affected by differences in count, but the labour content of that weight. I have seen the price of shoes used in a somewhat analogous way to cotton yarn count to allow for the effect on productivity of difference in the types produced in different factories.

All these methods for relating the outputs of different classes of products neglect the effect of any differences there may be between products within a class. For example, cotton yarns are twisted and those of a given count may differ in the turns of twist per inch, and consequently they may have different labour contents, which are not taken into account in the calculations of Mr. Shaw. Count is the major factor, but the labour content based on count alone is approximate to the extent that the neglected turns per inch and other minor

factors have an effect on productivity. Such approximations are less likely to be overlooked when the labour content is based on the full analysis of a time study than when determined empirically.

Differences in products are usually allowed for when measuring output and productivity because they are due to the requirements of the customers; they are not often part of manufacturing efficiency and so are not often the subject of investigation. Occasionally, however, they may be. For example, it may be desirable to measure the cost, in terms of productivity, of some limitation in design imposed by some safety regulation. Or again, differences in design in the products of two factories, differences that affect the ease of manufacture, may be due to the relative skill of the designers, and so be part of the productive efficiency of the factories; whether the measure should reflect such differences depends on whether total productivity or only operating efficiency is under investigation.

Productivity of Processes

The methods of measuring output so far described enable productivity studies to be made fruitfully over a wide field, but the field can be much widened if it is remembered that many final products contain common components or intermediate products, and if productivity is studied by measuring the output of the components rather than that of the composite article—by measuring the output, for example, of valves, coils, condensers, switches, &c., rather than of wireless sets. The Joint Committee of the Institution of Production Engineers and the Institute of Cost and Works Accountants goes further and recommends that attention should be focussed on basic processes rather than on products. Many workshops, for example, turn metal shafts for a wide variety of products; the products can be compared only with difficulty, but the process of turning is common to them all. The study of processes rather than products is a difference of approach rather than of principle, for process and product are inseparable; but the process approach is a most illuminating one.

One example is the study of the labour productivity at the speed-frames, one of the earlier processes in cotton spinning. A large part of the operatives' work consists in handling two types of bobbin: the supply bobbin and the produced bobbin. It takes approximately three times as long to handle one supply as one produced bobbin, so that a reasonably good measure of productivity is the equivalent number of produced bobbins handled per man-hour, which equals

(3 × No. of supply bobbins + No. of produced bobbins) handled per man-hour.

This is almost independent of the products, within limits, but is calculated from the weight of material produced and the average weight on a supply and produced bobbin. The measure is approximate in that it fails to take account of some appreciable elements of the work associated with the process. This example is equally one of the measurement of the labour content of the products, and so illustrates the point that product and process are two sides of the same medal.

All these methods of correcting for variety of products when measuring output require more detailed information than is usually given in the general official statistics such as those of the Census of Production, and the measurement of productivity from such data is a hazardous business as compared with its measurement with the fuller information given by detailed studies. For the purposes of studying industries as a whole, detailed studies may have to be made by sampling methods, but this presents no serious difficulties.

In one way or another measures of productivity can usually be devised for making comparisons for products or processes of the same general kind; that is, broadly, for making comparisons within industries. No measure is perfect in the sense that it automatically and certainly indicates the degree of technical, managerial and worker efficiency—the search for such a measure is like the search for the philosopher's stone. But too much should not be made of the imperfections. Measures that are in common use are good enough for most practical purposes, and British industry is far from achieving a uniformly high level of productivity such as would render all but very precise measures useless.

The making of "meaningful" comparisons of productivities between different industries and the precise measurement of the productivity of a group of industries or of a country's whole industrial system must await a better understanding of the measurement of output by value or labour content than now exists. Whether the understanding can ever be good enough for this purpose is a matter of opinion. But changes in productivity can be compared for industries and estimated for groups of industries. Thus, if for one industry output has increased by, say, 10 per cent and the man-hours employed by, say, 4 per cent, productivity may be said to have increased by approximately 6 per cent; and this may be compared with an increase of, say, 3 per cent correspondingly determined for another industry. Moreover, the percentage increases and decreases for a number of industries can be combined in an average. This process involves problems of weighting, of which statisticians have had considerable experience in forming index numbers. It is sufficient here to state that the superficiality of the available data and the uncertainties of sampling and weighting render current estimates of general increases only very approximate.

Interpretation of Results

There is no such thing as productivity in any absolute sense; it can only be defined and measured according to definitions that have to be chosen. The choice of definition depends largely on the purpose of the study and the measure depends somewhat on the data and facilities available; for example, no industry that has so far failed to realise the general uses of time study is likely to adopt it for the sake of productivity measurement. The chief necessity, however, is for the purposes of any productivity investigation to be defined in some detail; when that has been done the problem of measurement is a long way towards solution. Productivity measurement is being made in a variety of circumstances and for a variety of purposes; doubtless common elements in these circumstances and purposes will come to be recognised, and then it will be possible to adopt by convention standard definitions having a wide, though not universal, application.

When interpreting the results the significance of the definitions adopted must be borne well in mind. Seldom does a measure fit its purposes exactly, and often results are used for purposes other than those for which the measure was originally designed. Judgment has to be exercised in arriving at conclusions from productivity measurements.

Mention has already been made of the allowances that may have to be made for quality and for approximations in taking account of differences in products when deriving the measure; the following are further examples of considerations that arise when interpreting results. One producing unit may give a higher productivity figure than another partly because of natural conditions: coal is easier to win from American than from British mines; this complicates the comparison of the operating efficiencies. One unit may have a higher productivity figure than another partly because it makes larger quantities of a narrower range of products than another; this effect does not reflect the relative operating effectiveness of the units, but it may reflect commercial and political effectiveness in organising standardisation and simplification of products. Or again, failure to adopt machinery and manufacturing methods that lead to high productivity may reflect either lack of managerial foresight and efficiency, or conditions outside any industrialist's control, or both. It is difficult to allow for these things when deriving the measures of productivity, and to what extent allowance should be made when interpreting results is a matter of judgment.

The causes of differences in productivity are many; ingenuity can go a long way in taking these quantitatively into account when defining a measure, particularly if time study is used; and there is scarcely any limit to the possibility of making qualitative allowances. Indeed, in the limit all factors can be taken into account in one way or another, so that all differences in productivity disappear. Perhaps the best frame of mind in which to study productivity is not to seek to establish whether one producing unit or system is more or less productive than another, but to accept it that differences in productivity will occur, and to seek to measure them and analyse them into parts associated with the various factors.

Institution of Electrical Engineers Presidential Address

In his inaugural address as President of the Institution of Electrical Engineers, London, on Thursday October 5th, Sir Archibald Gill, surveyed some recent developments in telecommunication engineering in the public services of this country, with special reference to the telephone service.

Discussing switching Sir Archibald acknowledged the wise choice made by Sir Thomas Purves in 1925 when he decided to adopt the Strowger step-by-step system generally throughout the country, with director working for the larger cities. At present the possibilities of electronic switching were being studied so that advantage might be taken of the speedy operation of thermionic valves as compared with mechanical switches. Some of the initial difficulties had been overcome, and field trials under service conditions were to be carried out on a two-digit electronic director which had already been designed and tested.

After discussing recent progress in signalling in telephony, Sir Archibald spoke briefly of some of the rapid advances in long distance transmission over land and sea routes, with particular reference to the negative feedback amplifier and the coaxial cable which had solved the problem of cross-talk at the high frequencies required for multi-channel working. An interesting example among the recent installations was the composite coaxial and screened-pair cable between London and Birmingham. Important developments in the design of submarine cable included the introduction of carrier working as on land cables, the use of low-loss h.p. dielectrics, and of submerged amplifiers to permit the use of higher frequencies.

The Fifteenth Commercial Motor Show

No. III—(*Continued from page 350, Oct. 6th.*)

LACK of space prevents us from describing and discussing other interesting details of some of the smaller type commercial vehicles and vans, but we should like to mention in this connection the well-known "Land-Rover" of the Rover Company, Ltd., a four-wheel drive vehicle, fitted with a 50 h.p., four-cylinder engine of 1·6 litre capacity. The clutch and the four-speed main gearbox are built integrally with the engine. Incorporated with the gearbox is a transfer box with two gears, thus providing a range of eight forward gears. A third transmission shaft is provided transmitting power to the rear power take-off.

Since the initial announcement at the last Earls Court Show, that some of our leading manufacturers were to adopt underfloor engines in their passenger vehicles, this system has been the subject of lively anticipation and it is only natural that these vehicles are in the centre of interest for the many thousands of visitors.

Two of these vehicles, the Leyland "Olympic" and the A.E.C. "Regal" Mark 4, have been fully illustrated and described in our issues of January 27 and February 8, 1950. We also refer our readers to the description of the Leyland "Royal Tiger" chassis in THE ENGINEER for May 5, 1950.

One of the underfloor engine chassis on show is fitted with a forty-seater body of all-metal construction, built by Saunders Engineering and Shipyard, Ltd., fitted with an air-operated jack-knife entrance door forward of the rear wheel and similar exit door in front of the front axle. Another body, also seating forty passengers, has been designed and built by Leyland Motors Ltd. and is interesting because of its ventilating system, which gives a complete change of air every 2½ minutes. As the air inside the coach can be maintained at a higher pressure than the air outside, no air can enter the coach through chinks or small window openings and it is therefore draught-proof and dust-free. Four high-speed electric fans, two thermostatically controlled, are incorporated in the heating and ventilation systems, which force 550 cubic feet of air, heated when necessary, into the coach every minute. Air leaving the coach can also be used for cooling the diesel engine.

Two recent additions to the growing number of underfloor-engined chassis being produced in this country come from the works of Maudslay Motors, Ltd., and Crossley Motors, Ltd., members of the A.C.V. group of companies. Both are fitted with the A.E.C. 9·6 litre, six-cylinder diesel engine, mounted amidships, and developing 125 h.p. at 1800 r.p.m. The Maudslay chassis is fitted with a fluid flywheel and a separately

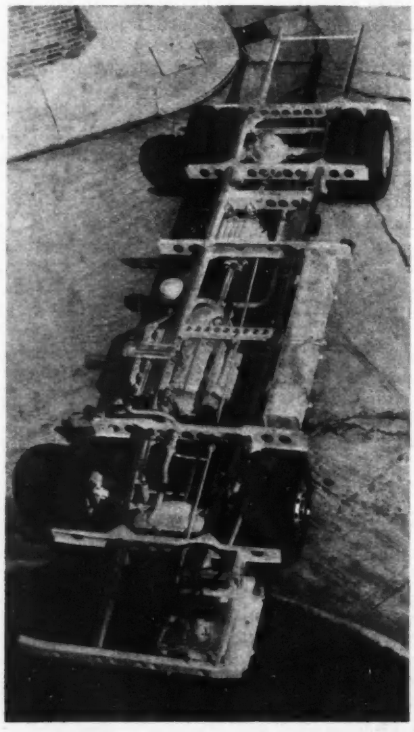


FIG. 6—MARK IV PASSENGER CHASSIS WITH A.E.C. UNDERFLOOR ENGINE—CROSSLEY

mounted four-speed gearbox of the Wilson type. The pre-selective gear lever is mounted on the steering column, the brake bands in the gearbox being operated by compressed air.

The Crossley chassis is similar to the Maudslay but the drive is taken from an orthodox single-plate clutch to a four-speed synchromesh gearbox (Fig. 6). The compressed air brakes are operated from a single compressor mounted integral with the engine crankcase and driven by an eccentric on the crankshaft. The radiator is mounted just forward of the front axle and the cooling fan is driven by a jackshaft from the engine. Semi-elliptic springs are fitted, a stabiliser being provided at the rear and hydraulic dampers at the front.

Prominent at the stand of Dennis Bros., Ltd., is the new "Dominant" machine, fitted with a 7·6 litre, six-cylinder engine. This engine, is developed from the well-known four-valve direct injection 0·6 engine, suitably modified for horizontal mounting, develops 100 h.p. at 1800 r.p.m., but the overseas version is fitted with a supercharger of the Rootes type, the drive of which is taken from the front of the engine. With the boost pressure of 6 lb per square inch, it raises the engine power by about 30 per cent. A special feature of the "Dominant" is the simple, unified arrangement of the control components. They are mounted on the control platform, which, whilst being available in either right or left-hand positions, is in reality part of the chassis structure.

A further interesting item of the "Dominant" is the transmission, the makers utilising the Hobbs semi-automatic hydraulically controlled gearbox. This gives finger-tip control without using a clutch pedal, ensuring complete absence of fatigue for the driver, and providing for smooth gear engagement in spite of the engine revolutions being inaudible from the driver's cabin.

At the last commercial show, in 1948, Fodens, Ltd., caused something of a sensation by the introduction of their two-stroke diesel engine, and now they are the first British makers to produce a rear-engine coach chassis to be fitted with either a Fodens or a Gardener six-cylinder engine. The engine is carried in the frame parallel to and behind the rear axle and has a right-angle spiral bevel drive incorporated with the clutch housing (Fig. 5). This housing has a large aperture facing to the rear of the vehicle, through which normal adjustments can be made or the complete clutch removed. The gearbox is of orthodox design, with either four or five speeds, and all gears excepting the low ones are constant-mesh and are engaged by multi-sliding dogs. A short propeller shaft is used between the gearbox and the offset underslung worm drive of the rear axle.

In support of the rear engine mounting, the manufacturers claim that the underfloor engine is not accessible enough for ordinary maintenance and causes a certain

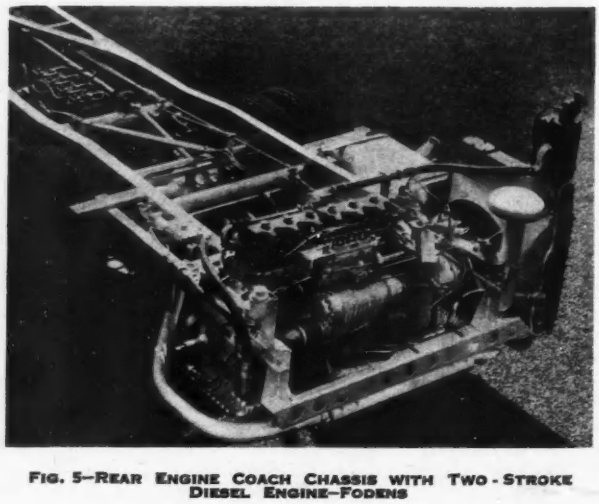


FIG. 5—REAR ENGINE COACH CHASSIS WITH TWO-STROKE DIESEL ENGINE—FODENS

FIG. 7—COACH SHOWING ACCESS TO REAR ENGINE—FODENS

amount of noise and vibration below the passengers in the centre of the body. Furthermore, in order to give the legal ground clearance, the frame height of the underfloor engine chassis is on an average 3ft 2in laden above the ground, making entrance and exit difficult, and owing to the higher centre of gravity tends towards instability on corners. The Fodens rear-engined bus has a frame height of 2ft 7¾in laden, up to the rear axle, then it rises upwards to a maximum of 2ft 10½in at the rear. Utilisation of the space at the rear of the frame enables the engine to be placed under the rear seats without loss of passenger space, whilst, upon opening the doors at the rear of the bus, all the vital parts of the engine are immediately accessible (Fig. 7).

It must be admitted that the protagonists of the rear engine system have a good case and it should be remembered that rear-engined coaches are being extensively and successfully used in U.S.A. as well as on the Continent. One of the still existing difficulties, the operation of the clutch, gear-change and engine controls by a system of rods, however, does not seem to be an ideal solution and the full benefits of the rear engine can only be derived by hydraulic or other remote control from the driver's cab.

(To be continued)

A Research Department of the Nuffield Organisation

WE were recently invited to visit a research department of the Nuffield Organisation at the Cowley Works, Oxford, and were able to observe the many aspects of motor-car research and development now taking place. The work of the department is mainly concerned with general mobile performance testing of prototype vehicles, with the development of appropriate recording equipment, and also of simulated performance test rigs, whereby whole or part assemblies undergo continuous repetition of their working cycle.

Perhaps the most important aspect of this work is that relating to the mobile performance tests during which the vehicle is subjected to the severest running condition both over specially chosen road surfaces and on simulated track dynamometers. The car can thus be subjected to loading conditions of a most complex nature, which in certain cases are designed to produce premature failure. Investigations into the nature and extent of vibratory stresses induced in the suspension systems and other components forms an important part of the research work and several interesting rigs have been devised. Sound and dustproofing are other aspects for which instrumentation has been developed.

The department is well equipped with engine test beds, which are mostly fitted with hydraulic dynamometers. The fitting of visual plastic cylinder head covers on test engines permits observation of combustion processes, which is particularly useful for cold-starting tests.

Mobile Performance Testing

In recording the performance of a vehicle undergoing these severe mobile tests, the recording instruments are themselves subject to the same violent conditions and the special apparatus that has been developed consists of modifications of the Cambridge vibrograph (stylus on celluloid) recorder.

Amongst the more important data required from the mobile test is a continuous time-displacement curve from which the velocities, acceleration and decelerations can be extrapolated. For this purpose a vibrograph recorder is installed, and imposed on the continuous recording film are three major signals: tenth-second intervals of time, each half revolution of a front wheel suitably wired with an electrical contact device, and marks indicating increments of distance covered. These marks are obtained by the familiar use of photo-electric cells and light source with mirrors spaced at 600ft intervals along the track; the complete mobile installation is shown opposite. By obtaining the wheel revolutions and the distance covered in this way a curve can be plotted showing for any particular speed the effective rolling diameter of the wheel, which becomes a function of the speed by virtue of the centrifugal loading on the tyre. It is then convenient to superimpose upon a chart sets of characteristic curves involving time and wheel revolutions for different speeds, using the corrected rolling diameters. The chart is fitted with a calibrated speed scale pivoted at the origin and is arranged to read directly the actual speed over the desired time increment knowing the wheel revolutions only, thus dispensing with the independent recording of displacement by the photo-electric cell.

Another adaptation of the vibrograph is used to record the relative displacements and accelerations of the suspension system with respect to the body. The type of track surface used for this purpose is the notorious Belgian *pavé*. Vertical movement of the front wheel is through a slow-lift cam bolted to the spindle of the shock absorber arm; as the wheel rises the cam is rotated, lifting a roller attached to the arm of the recording stylus. A similar cam arrangement is also employed for the vibration recorder in the rear of the vehicle, actuated by a pulley around which three turns of wire cable are wound before passing to a double spring anchored to the rear of the body. A mass type accelerometer on the floor of the car records vertical accelerations of the body. A common time base is provided for all the instruments by a single clock, thereby enabling all points on the film to be related to one another.

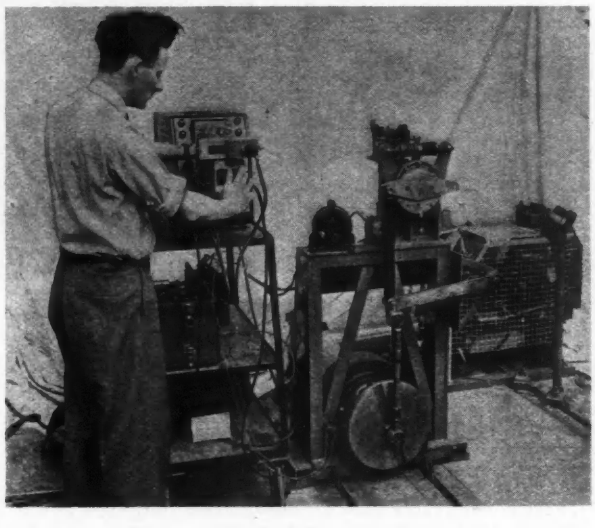
Road and instrument tests are supplemented by yet further trials on an apparatus known as a universal dynamometer. This consists of four large drums, on the surface of which are arranged bumps and hollows to imitate the rough surface of a colonial or overseas track. The drums upon which the car is mounted are driven at various speeds representing actual road speeds, and the severity of the test is such that in a run of fifty hours four sets of tyres can be worn out through fatigue of the tyre walls. The test is designed to reveal those components of a vehicle which are liable to suffer fatigue and to indicate probable design weaknesses. Tropical conditions can be simulated for this test.

Excess torsion tests are carried out by means of which all the necessary mechanical and ground clearances on the vehicle are measured and carefully checked. The work involves subjecting the vehicle to severe distortions, of which rounding a hairpin bend at the highest safe speed is an example.

Special equipment has been devised for investigating the problem of brake fading, which occurs when the brake lining and drum reach certain critical temperatures. The apparatus used comprises thermo-couples set in each brake drum and connected by wiring through slip rings to temperature recorders for rear and front wheels respectively. The car is then driven at constant speeds and the brakes applied, pressure on the brake pedal being measured and the decelerations being noted by a mass type decelerometer. This test is a very severe physiological one on the driver, involving brake applications at half-minute intervals with the car travelling at 50 m.p.h. to 60 m.p.h. for each application.

To obtain an exact interpretation of the records obtained from the Cambridge recorders, the experimental department has designed a special analyser for examining the wave forms traced on the recorder films. A magnification of ten times their actual size is obtained and they can then be retraced on to tracing paper,

VIBROGRAPH AND PHOTO-ELECTRIC APPARATUS



SHOCK ABSORBER LOAD REACTION TEST

the mechanism of this apparatus enabling a direct measurement to be made to within one-thousandth part of an inch.

Static Test Rigs

The test rig for shock absorbers, which is shown on p.361, comprises three members, namely, an adjustable crank which imparts movement to the arm of the shock absorber, a torque head to which the shock absorber is attached, and a vibrograph recorder which takes a permanent record of the torque variations during the test.

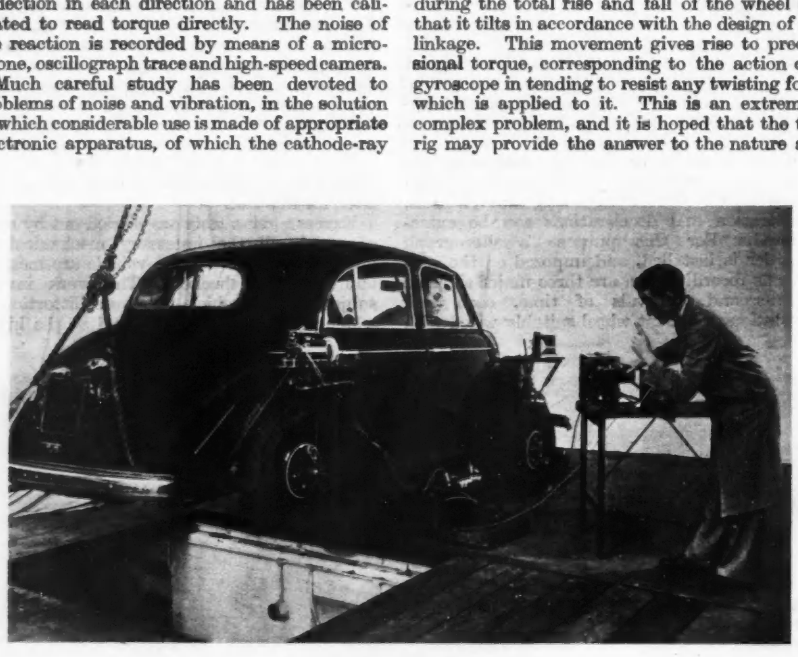
The torque head consists of a face-plate mounted on a shaft which is supported by bearings. The face-plate is restrained from rotation by two powerful springs mounted in opposition and under initial compression. Within the working range of the machine the deflection of the face-plate against the springs is proportional to the torque transmitted to the face-plate by the shock absorber. A dial gauge is fitted to give a visual indication of maximum deflection in each direction and has been calibrated to read torque directly. The noise of the reaction is recorded by means of a microphone, oscillograph trace and high-speed camera.

Much careful study has been devoted to problems of noise and vibration, in the solution of which considerable use is made of appropriate electronic apparatus, of which the cathode-ray oscillograph, a stroboscope and a wide range of pick-ups are typical examples. Technicians have also made a calibration bar by means of which it is possible to obtain displacements varying from zero to 0·030in, and thereby to correlate the graticule scale on the face of the cathode ray oscillograph with the movement of the components under test. The stroboscope is very simple to operate and can be used for the measurement of speeds ranging from 540 r.p.m. to a maximum of about 7500 r.p.m. The main use of the stroboscope is not so much for the measurement of speed but rather for the analysis of complex mechanical movements by coverting these into apparent slow motion, when the controlled frequency flashing light of the equipment is directed upon them. A special electronic method has been devised for measuring and recording torsional vibrational frequencies of camshafts.

Another magnetic type of vibrator is used to impart a definite acceleration to the car component under test, the principal objective being to vibrate the component at its own natural frequency for long periods. The vibration characteristics of the assembled vehicle are an indication of its rigidity, and the investigations involve mounting the car upon a platform, which is caused to vibrate on the principle of out-of-balance masses, which can be arranged to provide vertical and lateral movement (or both) of the car at both front and rear.

Another test rig which we illustrate has been evolved for reproducing the maximum conditions to be encountered when a car passes over an acute vertical curve in a road. The main objective is to test the reaction of various arrangements of springs and shock absorbers. The axle is first tied up with the spring fully compressed and then released instantaneously. The apparatus includes a deflection recording machine, an electronic accelerometer and a high-speed camera. From a knowledge of the mass and accelerations of the moving parts the forces on the system can be calculated.

A very important aspect of the design of a suspension system concerns the problem of what is known as "shimmy," or the horizontal oscillation of a wheel and of its component parts, such as the brake drum, around the king-pin. A gyroscopic test rig has been designed which records the oscillation wave forms of the front wheel on a vehicle travelling around a bend at a speed of 50 m.p.h. Vertical and horizontal oscillations were recorded against a common time base, and it was shown that the axis of the wheel does not remain perfectly horizontal during the total rise and fall of the wheel but that it tilts in accordance with the design of the linkage. This movement gives rise to precessional torque, corresponding to the action of a gyroscope in tending to resist any twisting force which is applied to it. This is an extremely complex problem, and it is hoped that the test rig may provide the answer to the nature and size of the forces involved. A front wheel, complete with steering linkage, is mounted on a bed-plate and driven at speeds corresponding to road speeds. At the same time, vertical movement is imparted to the assembly by means of a crank to correspond to the bumps in the road. Frequency of vertical movement can be altered at will, the effect of shimmy can be reproduced on the rig, and the various forces acting on the assembly can be studied and measured.



Axle Drop Test

Many other rigs have been developed for investigating the life cycle of components such as leaf springs, propeller shafts, torsion bars. An interesting machine used for investigating wear and lubricant characteristics employs a hardened steel ball rotated under load in contact with the specimen surface. The unit loading rapidly falls from the infinite to a state of equilibrium where no further wear occurs. The indent is measured and, knowing the peripheral distance travelled by the ball, the relative properties of the surface or lubricant can be suitably recorded.

Sweden's Iron and Steel Exports.—It is reported that iron and steel exports from Sweden in the first six months of this year totalled 84,500 tons, compared with 74,800 tons in the corresponding period of 1949. Exports of ore in the first six months of 1950 amounted to 5,430,000 tons, as against 5,670,000 tons in the first half of last year.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

SELF-PHASING OF LOCOMOTIVES

Sir,—Reference to the above by Mr. Livesay in his letter published in The Engineer of August 4th recalled some observations made more than twenty years ago, when the 2–6–0+0–6–2 Beyer-Garratt locomotives made their appearance on the L.M.S. Railway. A matter of great speculation amongst enginemen and fitters was why, after the locomotive had started from rest and travelled a short distance under load, the exhaust from two uncoupled engines, each with two cylinders and exhausting into the same blast pipe, appeared to settle down into a regular four beats per revolution. Many were the attempts made to watch the relative motion of the cranks of the separate engine units, but it was impossible, even at very low speeds, to co-ordinate the aural and visual indications received from each unit simultaneously and get any accurate idea of what was happening.

Eventually an opportunity presented itself to subject the question to closer scrutiny. Owing to the incidence of a heated coupled axlebox and the fact that the installation of a wheel drop had not been completed, it became necessary to uncouple the rear unit of a Garratt locomotive from the boiler unit to enable it to be lifted separately to attend to the defective bearing. During the work of reassembly, the wheels of the rear unit were arranged so that when the engine was ready to move again under its own steam, the relative crank axles of the two units would, or should, result in eight equally spaced exhaust beats per revolution being obtained. So keen was the interest that elaborate check was made of all crank angles—setting by the eye was not good enough for this (unofficial) test! Being a brand new engine the tyre thicknesses were virtually the same throughout both units, nevertheless all coupled wheels were calipered to confirm that their diameters were to all intents and purposes identical.

Then the locomotive was moved under its own steam, slowly and without load, on a straight track, and, lo! eight distinct beats were obtained. Opinion among the principals (two apprentices) and mere onlookers (the remainder of the shed staff with a good sprinkling of drivers) was almost unanimous that the beats were not quite evenly spaced and differed in intensity. This is not surprising when it is remembered that, neglecting bends, it is approximately 20ft from the cylinders of the front unit to the blast pipe, whereas the corresponding distance for the rear unit is about 50ft. There must be a difference in the pressure drop from the cylinders of the respective units to the blast pipe, also a difference in the time taken for the steam to reach the blast pipe from the respective units. The position of the cranks on the front unit appeared to have altered slightly relative to those of the back unit when the locomotive was stopped.

The next step in the investigation was to start the engine, apply the brake on both units, and give a good regulator opening. Within 30 to 40 yards, the aural indication was four beats per revolution only, although the exhaust sounded "woolly," and, when the engine was finally stopped under a full and continued application of the brake with the regulator still open, the last few exhaust beats were not at all distinct. The cranks of the two engines had abandoned their careful setting, and although no slipping had been noticed, it must have occurred. Certainly the crank settings were not such as to give four or eight equally spaced beats from the two units.

The result of the next test was more informative; the locomotive was again moved with a

good regulator opening and restrained by the brake, and it was considered, after careful observation by several people, that the four regular, heavy exhaust beats aurally and visually discernible corresponded with the periods of exhaust from the cylinders of the front unit, and the conclusion was reached that this (front) engine had the major influence on exhaust indications at the chimney whenever the locomotive was working at normal capacity and speed.

During the intervening years the writer has ridden many times upon Beyer-Garratt engines and can confirm Mr. Pickett's observation that the cranks, when stopped, are usually at "any old angle," this, even after working with four nice regular beats, albeit somewhat "woolly," shutting off steam on perfectly straight level track and drifting to a stop without a brake application. It seems that, when account is taken of the incidence of track curvature, probable differences in the rate of tread wear on the coupled wheels of the respective units, and different degrees of slipping of the latter, the cranks will never phase for any length of time to produce a clear-cut four beat exhaust at the chimney, which is the result of the simultaneous union at the blast pipe of the separate exhaust from the two units.

Can it be that the long exhaust pipe from the rear unit acts as a kind of receiver, and that when the exhaust from the front unit with its superior pressure and speed leaves the blast pipe, it induces a quantity of steam from this receiver to go with it, the two exhausts appearing as one except at starting when the time lag is sufficient for both to be aurally and visually apparent, provided the crank settings are suitable? This tentative view is strengthened by the impressions gained on a more recent trip on the ex-L.N.E. Beyer-Garratt six-cylinder locomotive, No. 69,999, when working on the Lickey incline, for after the first few yards of movement whilst pushing a heavy train up the bank, the aural indication was six regular beats per revolution.

W. G. F. THORLEY

Castle Bromwich, September 15th.

PRIDE IN WORK

SIR,—I write to express appreciation of "L. P.'s" letter under the above heading. Incidentally, I have recently seen the production methods in the works mentioned, and I commented that "it seemed that personal interest in quality of work belonged to the motion-study staff rather than the operators." Coupling this visit with others to works with reputations for mass production, I am troubled by industrial tendencies to put speed beyond the pleasurable limit of the workers. At one factory I was told that dog racing, and the gambling that goes with it, was the natural relaxation for the workers; their minds were dulled, their bodies were tired, and to stand and watch, with the excitement of a gamble, was all that was desired.

Supervisory and managerial staffs are also affected. Government propaganda and instructions, joint consultation, appointment and training of executives, with little regard for practical experience, entail a considerable amount of organisation and expense in their operation, which is not only an appreciable surcharge on production costs, but brings about a condition that every job is everybody's job and nobody's responsibility. As "L. P." would state, "all this in a world crying out for food."

Are we not getting used to the idea of working for our wages or salary, without the spiritual satisfaction of pride in our work?

C. J. P.

Coventry, September 19th.

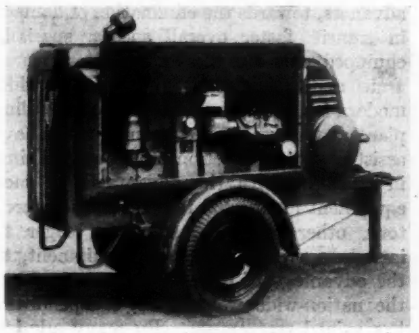
A Small Portable Air Compressor

WE illustrate below a new single-tool portable air compressor, which is now being manufactured by the Atlas Diesel Company, Ltd., of Wembley, Middlesex. In this unit, which is designed to deliver up to 63 cubic feet of free air per minute at 100 lb per square inch, both the diesel engine and the compressor are air cooled.

The power unit is a two-cylinder, air cooled, diesel engine manufactured by Armstrong-Siddeley Motors, Ltd. Its cylinders have a bore and stroke of 4¼in by 4¼in, and the engine develops 20 b.h.p. at 1400 r.p.m. The engine is cold starting and has direct injection, provided by a standard C.A.V. fuel pump and injectors, governing being effected by controlling the quantity of fuel as the load on the engine varies. The finned cylinders and cylinder head are directly air-cooled by a flow of air from the vaned flywheel, which forms a centrifugal fan and delivers a cooling air blast via a spiral cowl. The air passes first through tubes placed longitudinally through the crankcase, providing effective oil cooling.

Drive is transmitted from the engine to the compressor through a substantial "Flexaire" automatic centrifugal clutch.

The bores of the low and high pressure cylinders of the two-stage compressor are 6¼in and 7¼in, respectively, and the common stroke is about 3in. It has light weight sprung-disc suction and delivery valves, designed to give a high volumetric efficiency under all pressure variations. The large diameter flywheel-type fan which operates in a volute shaped casing and supplies cooling air to the compressor also draws air along the compressor crankcase, to assist in oil cooling and passes it through a large intercooler. When running at 1400 r.p.m., the compressor has a piston displacement of 78 cubic feet per minute.



PORTABLE AIR COMPRESSOR

The complete unit is mounted on a fabricated steel chassis carried on a spring axle and two pneumatic tyred road wheels. A welded steel drawbar of box construction incorporates a retractable support leg and handle-bars to facilitate manœuvring on site. Non-detachable steel side curtains are arranged for folding up when the compressor is in use and can be locked when in the closed position.

We are informed that the firm also supplies an equivalent petrol engine driven set, powered by a "Standard" 22½ h.p. four-cylinder engine.

OBITUARY.—We regret to announce the death, on September 16th, after a long illness, of Mr. George Senior, until recently a director of General Refractories, Ltd., Sheffield. Mr. Senior, who was sixty, had been associated with the company for thirty-one years and was a director for the last fifteen years.

SUGAR BEET HARVESTING MACHINERY.—The fifth annual demonstration of sugar beet harvesting machinery is to be held on October 19th and 20th at Carr House Farm, East Heslerton, Yorkshire. The crop to be dealt with occupies 70 acres and twenty-five harvesters and many other ancillary machines will be at work. The demonstration is being arranged by the British Sugar Corporation, Ltd., and the National Agricultural Advisory Service.

Canadian Engineering News

(By our own Correspondent)

N.R.C. Appointment

The appointment of Dr. E. W. R. Steacie, Director, Division of Chemistry at N.R.C., as Vice-President (Scientific) of National Research Council, has been announced. In his new post Dr. Steacie will be responsible under the President for the co-ordination of all scientific activities in the N.R.C. organisation to ensure that the work of the several divisions proceeds according to a general plan, and that the closest integration of research is maintained throughout the laboratories. An important aspect of the new appointment is that it will not in any way affect Dr. Steacie's present research activities, since he will continue in the directorship of the Division of Chemistry where he has built up a research group in chemical kinetics that has won world acclaim. Dr. Steacie became Director of the Division of Chemistry in 1939 and during the war served as Deputy Director of the British-Canadian Atomic Energy Project (1944–46). He was closely associated with Dr. Otto Maass, of McGill University in the organisation of Canadian chemistry for war purposes, especially in chemical warfare and in the development of explosives.

Niagara Project

Work will begin soon on a large power development at Niagara which will give the Province of Ontario an additional 900,000 h.p. of electrical energy. Following the recent announcement from Washington that the United States Senate had ratified the treaty for diversion of additional water from the Niagara River, Chairman R. H. Saunders, of the Ontario Hydro-Electric Power Commission, stated that the Commission would be able to go ahead within a few weeks.

Cost of the development has been estimated as high as 200,000,000 dollars. The power output from the new plant will probably meet Ontario's power requirements at least until 1958, and possibly later. In addition to the building of the actual plant, a tunnel or canal will have to be cut through almost solid rock, to carry water from above the falls to the Queenston area.

The treaty, passed by the Canadian Parliament on June 14, 1950, provides for the increased diversion of water from the river to power uses. The water resources are equally divided between the United States and Canada. Protection of the scenic beauty of the Falls is assured by the limit on the amount to be diverted.

According to Ontario officials, present plans do not call for an open canal cut across the city of Niagara Falls, Ontario; the water will be diverted from the upper river, to be carried underneath the city in a tunnel to an open canal near Queenston. The prospective plans are as follows, according to the Commission's chairman:—

An underground tunnel will start at a point on the Canadian side of the river, ¾ mile above the Horseshoe Falls, between the submerged international weir, constructed during the war, and How Island. Water from the upper river will be fed through this tunnel, threading its underground path mostly beneath hydro right-of-ways, under overhead transmission wires crossing two streets, to a point near the whirlpool, situated in Stamford township on the lower Niagara River parkway. From there there will be an open canal cut, which will carry water into a new plant to be constructed approximately 100ft south of the existing plant at Queenston. Both plants will operate jointly. Over the entire route from the entrance to the tunnel in the upper river to Queenston, the water will flow on a downhill course.

Loss of power from debris in the present hydro canal which feeds into the big Queenston plant, is serious. Present plans call for a complete clean-up in the canal, but this work will have to await completion of the new tunnel and canal.

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NOTICE TO READERS

All letters intended for insertion in THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

For Subscription Rates, see page 2 of Advertisements.

PRINTING DIFFICULTIES

We regret that owing to the continuance of the dispute in the printing trade to which we referred in a leading article last week this issue has to be an "emergency" number heavily reduced below the normal size.

AMERICAN RAILWAY EXPENDITURE

IN the administration of railways of the magnitude and national significance of those of the United States, there tends to develop a definite ratio between net receipts and the amount set aside each year for new work, either in the form of rolling stock, civil engineering tasks or traffic handling facilities. By taking all the railways of the country and averaging the results, sudden spurts, or periods of retrenchment, that the impact of local conditions might force upon any one administration, are reduced to their importance relative to the overall situation, and a representative result is obtained. Prior to the war expenditure on purchases of new equipment and materials, taken over a twelve-year period, was 11 per cent greater than the net operating income earned. During the war, tremendous increases in expenditure were needed to provide stock and facilities to handle the extra traffic. The 686 million dollars spent annually during the 1929–1940 period soared to an annual average of 1234 million dollars in 1941–1945. The net operating income earned during those four years was such that the ratio of income to this item of expenditure was actually increased the revenue being 1160 million dollars, against the 1234 million dollars of expenditure. The altogether exceptional conditions that have developed in the railways of the United States since the war are reflected by the corresponding income and expenditure figures for the years 1946–49: only 771 million dollars in net operating income earned, against 1861 million dollars in purchase of equipment and material. As our American contemporary, *The Railway Age*, comments: "Never before in history have the railways gambled so much on the future as they are gambling now, to provide the nation's shippers with good and adequate services."

A high proportion of the money already spent, no less than that involved in the orders so far placed in 1950, is allocated to locomotives and freight cars. During the years of depression there was a natural disposition to "make do" with box-cars that were deteriorating with age, and the onset of war made it imperative to press into service almost anything that could turn a wheel. The expenditure figures of 1929–1940 are thus not truly representative of a sound, balanced economy, any more than are those of the war years. But even with this reservation, the post-war expenditure is still exceptional by comparison. Freight vehicle design has made notable advances, towards the elimination of damage in transit, faster overall speeds, specially equipped cars for the bulk conveyance of fruit and other perishable goods, while modern installations of mechanised handling plant at terminal and exchange points have assisted in the reduction of the overall time in transit. With the advantages of such equipment manifested in neighbouring territory, other railways have been eager to introduce similar plants and equipment, to the advantage of their own customers, and the nation-wide wave of high expenditure has gained momentum. By many administrations it is felt that by this means there is some chance of regaining a proportion of traffic that is being lost to the roads, but that without it there is none. On the passenger side new and attractive trains are constantly being put into commission; ever-increasing attention is paid to interior appointments and good-riding qualities, and the aggregate of high-speed mileage is greater than ever before. More even than this, the American railways have, since 1929, gradually improved their safety record till it is now fully comparable with that of the British railways. This welcome improvement can be traced to the increasing use of block signalling, centralised traffic control and, in some areas, to the use of continuously controlled cab signals, all of which items tend to swell the total of expenditure.

In commenting upon current trends in American railway practice reference is often made to the sales value of new devices, and to the public's love of novelty in almost any form. The sweeping advance of diesel-electric traction has to some extent been attributed to this trait, and this particular advance seems to be gaining, rather than slackening in momentum: thus orders for locomotives during the first three weeks of June, 1950, amounted to 1108, all diesel, compared with 290 diesel, thirteen steam and seven electric during the corresponding period of 1949, and again, with 461 diesel and fifty-nine steam in 1948. While a streamlined, garishly-painted diesel-electric locomotive may have a certain advertising value for passenger trains, in the end it is the ultimate performance that counts. After the war, when new and enhanced motive power was needed, the American railways found almost "ready-made," a tool, in the multiple-unit diesel, that more than met their immediate needs and since then huge sums have been invested in it. It has been claimed that the diesels have attracted passenger business, and that improved freight service has been made possible through their introduction. From the trader's point of view the form of motive power is immaterial; to them it is the quality and speed of service that counts, and it is in this direction that the American railways are now making such great efforts. On the other hand, railway engineers in many parts of the world may well seek precise statistics to judge whether in the long run diesels are likely to prove more economical than modern steam locomotives, such as those of the Norfolk and Western. This, however, is a question to which we shall probably never know the answer. In America steam locomotives are, to all appearances, a dying race, and comparison between the diesel-hauled trains of to-day and the steam-hauled trains of ten to fifteen years ago would be on such unequal terms as to provide unreliable results.

Obituary

SIR JOHN JARVIS, BART.

SIR JOHN JARVIS, whose death occurred at Godalming, Surrey, on October 3rd, will be remembered particularly by his work in reviving industrial activity in the Tyneside area during the inter-war economic depression. Guided by his wide experience of finance and industry, Sir John initiated, in 1944, the "Surrey scheme" to help the distressed area of Jarrow, and after raising a fund totalling about £40,000, he was instrumental in starting up five new industrial concerns on Tyneside, which provided employment for 5,000 people. Sir John was chairman of Sir W. G. Armstrong Whitworth and Co. (Ironfounders), Ltd., Gateshead-on-Tyne, and its two associated companies, and was also chairman of Jarrow Tube Works, Ltd., J. Jarvis and Sons, Ltd., and J. and A. Churchill, Ltd. For 15 years, until the last general election Sir John was Member of Parliament for Guildford. He was created a Baronet in 1922 in recognition of his services to the Government concerning financial and industrial problems during and after the first world war. Sir John was in his seventy-fifth year.

SIR RALEGH PHILLPOTTS

WE record with deep regret the death of Sir Ralegh Buller Phillpotts, which occurred on October 1st at Liverton, Newton Abbot, Devon. He had been chairman of the British Tabulating Machine Company, Ltd., since its incorporation in 1907. Sir Ralegh, who was created a Knight in 1946, was the only son of the late Mr. William Francis Phillpotts, Barrister-at-Law. He was born on October 22, 1871, was educated at Winchester and Balliol College, Oxford, and was called to the Bar in 1894. From 1901 to 1904, Sir Ralegh was secretary and legal adviser to the British Westinghouse Electric and Manufacturing Company, and, in the three years following, occupied a similar position with Speyer Brothers, Merchant Bankers. He was admitted a Solicitor in 1907 and became a partner in the firm of Surtees Phillpotts and Company, which was later amalgamated with Linklaters and Paines. Shortly after the first world war, in which Sir Ralegh

served with the Devon Yeomanry, he retired from practice as a solicitor and devoted a great deal of his time to county affairs. He was a Justice of the Peace, a governor of Seal Hayne Agricultural College, and chairman of the Devon Branch Executive Committee of the Council for the Preservation of Rural England. Throughout, however, Sir Ralegh maintained his active association with the British Tabulating Machine Co. Ltd., to the growth and development of which his industrial and legal experience contributed much. As well as being chairman of that company from its inception until the time of his death, Sir Ralegh was managing director from October 1938 until March 1945.

Parsons Memorial Window at Westminster Abbey

On the death of Sir Charles Parsons in 1931 the Royal Society set up a committee to arrange for appropriate memorials. One of its actions was to provide annually for the delivery of a "Parsons Memorial Lecture." Several such lectures have since been reported in our pages. Another was to make a contribution of £10,000 towards the cost of the Parsons Memorial Library at London House, Bloomsbury, which was opened by H.M. Queen Mary on December 3, 1937. A third action was that of approaching the Westminster Abbey authorities with the object of arranging that Sir Charles Parsons' name and achievements should be suitably commemorated in the Abbey amongst the names of other great men who have benefitted this nation and humanity at large. That last action reached fruition on Thursday, October 5th, when, at a simple ceremony in the Abbey, Sir Robert Robinson, President of the Royal Society, invited the Dean of Westminster to dedicate a memorial window designed by Sir Ninian Comper to commemorate Sir Charles Parsons. The window is on the North Side of the nave of the Abbey. It completes a trinity of such windows commemorating great engineers of the past.

At the ceremony Sir Frank Smith, Chairman of the Royal Society Committee and himself the first Parsons Memorial Lecturer, delivered a Memorial Oration. Unfortunately, owing to circumstances in the printing trade over which we have no control, we are unable to print that oration in full. Sir Frank referred to Sir Charles as "a great scientist, and in the judgment of many, the greatest steam engineer the world has known." Naturally his Oration was particularly concerned with the development by Sir Charles of the steam turbine for land and marine use and the accompanying high speed dynamos. For the name of Parsons will for ever be connected with that work. As Sir Frank put it "it is to Parsons more than any other man that credit is due, not only for the conception of the steam turbine, but for the subsequent movements which have led to the gigantic turbo-generators in the electric power stations of the world and the turbines which drive the biggest ships of the Navy and the Mercantile Marine." But if main place in the Oration was given to the turbine achievements of Parsons, other aspects of his work were not neglected. "He experimented with rockets to propel torpedoes; developed a loud speaker which was used at concerts; experimented with flying machines; investigated, designed and manufactured large searchlight mirrors; erected the first closed circuit water tunnel for investigating the effect of cavitation on ships' propellers; made large reflectors for astronomical telescopes and started to make diamonds." Coming towards his conclusion Sir Frank remarked that to him Parsons' outstanding achievements "were his insight into the mechanisms of nature, his wonderful engineering knowledge, his great experimental ability and his amazing courage in face of technical difficulties."

On the conclusion of the Oration Sir Robert Robinson asked the Dean of Westminster to accept the window on behalf of the Abbey and to dedicate it. The Dean having done so, the ceremony was brought to a conclusion by the recital of the Lord's Prayer.

Literature

Heat Pumps and Thermal Compressors. By S. J. Davies, D.Sc.(Eng.). Ph.D., M.I.Mech.E. London: Constable and Co., Ltd., 10 Orange Street, W.C.2. Price 8s.

In these days of the making of books dealing with the heat pump, there appears to be no end. Of the several books that have appeared recently emanating either from England or America, the one by Professor S. J. Davies is definitely to be commended. It is written by a professor who is in daily touch with students and who is used to imparting knowledge in a useful and economic way. If, for no other reason, the book will appeal to English readers.

It comprises basically a publication of the contents of four lectures, originally intended for advanced undergraduates. Realising the growing interest and importance of the heat pump to engineers, in general, the lectures were amplified so as to form one of the courses of public lectures at King's College, London. Practice and theory are very well interwoven, and the first lecture deals with the thermo-dynamic aspect of the subject. It is very interesting to know that the author has devoted some space to a discussion as to the most suitable term to use to consider the efficacy of operation of the heat pump. Quite properly the author decides that the term "Coefficient of Performance" is not the correct term to use when referring to the efficacy of the operation. He refers to Sumner's proposal to use the term "reciprocal thermal efficiency" and Faber's proposal to use the term "advantage" with a note that the French use the very interesting term "coefficient of amplification." In a desire to emphasise that a ratio is in question, the author proposes a new term known as the "performance energy ratio."

The second lecture examines in some detail various installations of large heat pumps, i.e., those which were installed in Norwich, at Zurich City Hall and at the swimming baths, and a very interesting installation at the Steckborn Artificial Silk Company's works in Switzerland. Limitations of space probably have prevented reference to the still larger installation at Zurich, which supplies district heating to a fairly large area, including the Technical College and blocks of shops and offices. This lecture contains a very interesting examination of the advantages of heat storage when using electricity as the prime mover for the heat pump.

The third lecture, devoted to a consideration of heat pumps wherein the working substance is mainly in gaseous form, is distinct from the first lecture, which is limited to a consideration of those cases in which dry air is the working substance, and in which the cycle of operations is that of the Joule cycle for constant pressure. Data are given in this third lecture relating to specific heat pump air-conditioning plants in America and Switzerland.

The fourth lecture examines the possible overall efficacies of the heat pump operation when using internal combustion engines, electric motors and oil engines respectively as the prime movers, and there is an interesting examination made as regards the jet thermal compressor and also the Philips hot-air engine with an indication of the potentialities of this machine, which, of course, operates on the Stirling cycle.

In general, the author makes a very complete, although necessarily cursory review of the factors affecting heat pump design and operation. He is clearly cognisant (as relatively few engineers appear to be to-day) of the urgent need to conserve fuel and evidently the author has in mind that there are limitations looming prominently before us in connection with the "letting down" of high-grade heat. His statement that "in this country, in view of the need to economise in fuel and energy, waste of low-grade heat in space heating and in industrial processes, without full consideration of the possibility of its utilisation, is inexcusable," would appear to be the inspiration that lies behind the book. He is not pessimistic about the future of heat pumps, but tries to give a fair review as to the present-day relative cost of providing heat by various alternative means, as is shown in Table IV, 1, on page 108, which gives a very interesting comparison between the thermal efficiencies, &c., when using coke-fired boilers, and heat pumps using electric motors or oil engines as the prime movers. It is very interesting to note that in the case of the heat pump driven by an oil engine he indicates a thermal efficiency as high as 228 per cent when the heat pump is used in summer; and a reciprocal thermal efficiency of 3·5 for use in winter and of 6·5 during the summer period when driven either by electric motors or oil engines.

The excellent discussion in the fourth lecture, which deals with thermal compressors, as regards the jet compressors and also the Philips hot-air engine, is novel and should be of very great interest.

The author states that the book has been written for practising engineers, as well as advanced undergraduates, and there is no doubt that the manner in which the subject has been dealt with will result in the book being of value to all those who are interested in the subject of heat pumps. The author makes the interesting comment, which is sometimes overlooked by authors from other countries who have written books on the heat pump, that the principles of the heat pump "owe almost everything to the contributions, in the early part of the last century, of Kelvin, Joule and Stirling in this country, although most of the practical applications of these principles have been made abroad." No reader need be deterred because of the reproduction of lectures into book form.

Rarer Metals. By J. de Ment, H. C. Dake and E. R. Roberts. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 25s.

The, at one time, purely academic interest in the rarer metals has now extended into technical and commercial spheres, and a concise account of the mineralogy, chemistry, physics and technology of the less familiar metals, such as is presented in this book, is to be welcomed on account of the growing importance of these elements and their alloys. Originally an American book by J. de Ment and H. C. Dake, the present edition contains additional chapters on the alkali and alkaline earth metals, boron and rhenium by the British editors, Dr. E. R. Roberts and Mr. R. C. Williams. No additions have been made to the American text published in 1946, with the result that some recent work in research and technique is not included. Thus, there is no reference to the Brush Beryllium Company's method of producing beryllium by reduction of the

fluoride with magnesium, nor to the recent achievements of the Climax Molybdenum Company in the production of cast molybdenum, nor to the work of the Battelle Memorial Institute and of the U.S. Bureau of Mines on titanium and its alloys. The metals of the rare earths are excluded from consideration.

The mineralogy of the rarer metals is fully treated. A description of their chemical properties is prefaced in most cases by an interesting historical note. The actual and possible methods of extraction from ores and preparation of the metal are adequately summarised, though under gallium the description stops short at the separation of gallium oxide and does not mention the preparation of the metal by the electrolysis of an aqueous solution of sodium gallate. Physical properties are given in detail, though the state of purity of the metal to which they apply sometimes makes their true values uncertain. The sections entitled "Technology" are of special interest. Under this heading many important practical applications of each of the metals are described. These range over a wide field and may absorb, in some cases, a few grammes and in others a considerable tonnage of the metal. On the application of the rarer metals as alloying elements in steel or in non-ferrous alloys the information given seems, in places, to be somewhat indefinite. Extravagant claims are sometimes given the same weight as some quite genuine and important effects, and there are too many phrases of the type: "Molybdenum increases the elongation of steel very considerably," or "An important use of ferro-titanium is in high-chromium steels," which, without amplification, convey very little. The latter phrase may refer to the use of titanium in heat-resisting steels, or in eliminating susceptibility to weld decay in austenitic steels, though the only reference to this defect is found under "columbium," where the composition of 18 : 8 steel is incorrectly given in this, as in the American edition, as 18 per cent nickel and 8 per cent chromium. Methods of chemical analysis and test are recorded, including numerous colorimetric and microchemical tests. The use of ultra-violet light in the fluorochemical method of detecting and inspecting tungsten ores is described as well as the fluorochemical analysis of beryllium, indium, molybdenum and uranium.

The authors do not intend their book to be a comprehensive treatise on the metallurgy or analytical chemistry of the rarer metals. It is described as suitable for "supplementary reading in science and engineering courses." Readers are expected to possess or otherwise acquire a more intimate knowledge of the aspect of the subject in which they are interested, and to use their judgment accordingly. The literature of the rare metals is enormous in extent. With lapse of time much of it becomes valueless. The authors have collected all information of fundamental importance falling within the scope of their book. In presenting this in a concise and readable form they earn the gratitude of the discriminating reader.

Hardenability and Steel Selection. By W. Crafts and J. L. Lamont. London: Sir Isaac Pitman and Sons, Ltd., 39-41, Parker Street, Kingsway, W.C.2. Price 35s.

Differences in the response to heat-treatment of different steels have long been recognised, but the concept of "hardenability" in its technical sense received its first application in America in the early days of the war. To meet the shortage of alloying elements, alternative steels had to be devised and effective use made of the alloy content of scrap. The work of Grossmann on the effect of chemical composition and of grain size on hardenability, and that of Jominy in providing an end-quench hardenability test, was applied to the development of the first batch of National Emergency steels, which were put into immediate production without the customary long period of testing and preliminary trial. The success of this venture led to suggestions that steel specifications might be based entirely on hardenability as measured by the end-quench test. Subsequently, while the hardenability concept retained its importance, a more reasonable and balanced view of the subject prevailed. As the late Mr. H. W. Gillett of the Battelle Memorial Institute wrote in 1944: "The user must, by some means or other, supplement the hardenability data by specific tests of his own to insure adequacy for his use. Equivalence of hardenability merely nominates candidates for scrutiny." Deductions to be drawn from end-quench tests, and the correlation between hardenability, tensile strength and yield strength, ductility and toughness were generally viewed with more caution in this country than in America. This attitude received support from results communicated to the Iron and Steel Institute's Symposium on the Hardenability of Steel (1946), to which Messrs. Crafts and Lamont were valued contributors. They are, indeed, outstanding among those who have worked to establish the application of the hardenability concept on a firmer basis; and their book may, therefore, be regarded as an authoritative statement of the present position. The correlation of mechanical properties with different types of microstructure and hardenability performance was a feature of the British work, but the results described and opinions expressed at the Symposium find no place in the book. The importance of structure, strength and toughness are, however, fully appreciated by the authors who hold that the desired values can be obtained by control of heating, hardening and tempering of any steel of suitable hardenability. The required dimensions, strength and toughness define the necessary degree of hardenability and this defines the total effective content of alloying elements. The recommended selection procedure appears to be, first, an appraisal of the service requirements and their interpretation into tangible mechanical properties, the most important being tensile strength and other qualities, such as yield strength, ductility and toughness, being related to tensile strength by hardenability. Estimation of the composition and heat-treatment necessary to develop the desired tensile strength is then accomplished by a series of simple calculations. It is possible, thus, to arrive at a group of steels having similar qualities from which the choice is to be made. Further selection may follow by eliminating the steels that tend to give undue trouble in processing. It is important to recognise that the property relations discussed hold only for longitudinal specimens and may have no application to transverse tests.

A question of terminology perhaps deserves mention. The authors usually refer to the results of the notched-bar impact test as "impact value" or "impact resistance" (the latter alone appears in the index), but they also in many places use the term "impact strength." Its inappropriateness is seen in such statements as that "the Izod impact strength of fine-grained alloy steels was inversely proportional to the tensile strength." An exactly parallel statement is made elsewhere about elongation and about reduction of area; and the impact test is stated to have been preferred to these as a "more sensitive criterion of ductility." It is misleading to associate the term "strength" with a property which depends essentially on capacity for plastic deformation under certain conditions of constraint.

The subject of hardenability control is bound to be one of increasing importance in the future as methods of heat-treatment attain greater precision. Metallurgists and engineers responsible for the selection and heat-treatment of steels will profit by a study of this book and derive assistance from the systematically assembled data that it contains.

SHORT NOTICES

The Solidification of Castings. By R. W. Ruddle. London: The Institute of Metals (Monograph and Report Series, No. 7). Price 10s. 6d.—In this survey of the literature of the solidification of castings, attention is concentrated mainly on the mathematical study of heat abstraction and the rate of solidification of cast metals, including the results obtained by the electrical analogue method, and on a comparison of the theoretical deductions with direct experimental evidence obtained by the "bleeding" of ingots and castings of simple form and by measurements of temperature distribution in castings. These data and calculations refer almost exclusively to steel castings. On the more practical side, covered by the twelve pages constituting Part I, emphasis is laid on the importance of the principle of directional solidification, and the various means available for controlling the rate of solidification in castings are briefly described. The book, however, is mainly of interest to the research worker for whom it provides a comprehensive statement of previous work. At the conclusion of the review the relative validity of the more fundamental methods of studying the problem is assessed. In connection with the theoretical approach the tables of thermal properties of metals and mould materials, contained in the appendix, will be found most useful, though, as the author points out, information is still incomplete and some of the data recorded are unreliable.

The Technical Aspect of the Design of Roads. By Stewart Champion, M.Sc.(Eng.), A.M.I.C.E. London: The Technical Press, Ltd., Gloucester Road, Kingston Hill, Surrey. Price 30s.—An attempt has been made in this book, which discusses current methods of approach to the design of roads, to provide a broader basis of understanding than a normal text-book. Thus it assumes a knowledge of general principles, describes the present position of development, and indicates some pointers to the future of road design. It is divided into three sections, the first of which deals with the layout of roads, including surveys and the design of highway curves and sections. The second section is concerned with soil mechanics, and discusses the soil survey, the classification and testing of soil, and the preparation of soil bases. The design and testing of the pavement itself is dealt with in the third section, which contains chapters on the design of flexible pavements, bituminous testing, the design of rigid pavements and testing work connected with concrete. The constructional aspect of road work has not been dealt with in this volume.

The Iron and Steel Industry

The Minister of Supply has announced that February 15th, 1951, is to be the general date of transfer to the Iron and Steel Corporation of the securities of the 92 companies specified under the Iron and Steel Act, 1949. It is also announced that Mr. S. S. Wilson has been appointed secretary of the Corporation.

Figures published early this week by the British Iron and Steel Federation show that steel production in this country in September was at an annual rate of 16,964,000 tons, and that total steel output in the first nine months of this year amounted to 12,117,000 tons.

Railway Overhead Line Inspection Vehicles

TWO Diesel driven vehicles have recently been completed and delivered to the Eastern Region of British Railways by the Drewry Car Company Ltd. for inspection and maintenance work on the overhead line equipment of the Liverpool Street–Shenfield and the Manchester–Sheffield electrification schemes.

The vehicles will be used mainly when the 1500V current is off and, to allow of thorough inspection of the overhead line equipment, the vehicles can travel at the low speed of 1½ miles per hour. Windows set at 45 deg. and fitted with windscreen wipers are provided at each end so that inspection can also be carried out from the interior of the vehicle, while universally mounted searchlights allow of light being directed on any part of the overhead equipment.

A hydraulically operated tower is housed in a well in the vehicle body and can be raised to any height convenient for working on, or examining the overhead line equipment. The raising and lowering of the tower is controlled by push button switches from its platform, and the vehicle can run while the tower is being raised or lowered as necessitated by the height from rail level of the conductor. Light extending ladders are secured to the vehicle exterior and are available for reaching any point outside the range of the tower. Floodlights are carried and can be secured to any convenient point. Spotlights can be plugged into sockets on the tower platform and fixed on the platform handrails, which fold down on to the platform when not in use. The roofs are flat and the whole of the space not occupied by the tower is boarded for use as a working platform.

The appearance of the vehicle with the tower raised and the platform handrails in position is illustrated herewith; access to the platform is by extending ladder attached to the tower. Another illustration shows the opposite (engine) end.

The interior of the vehicle provides space for up to eight men including driver. A work bench fitted with vices and with racks below for tools and stores is provided; a large locker contains bulky stores and equipment, and rails are mounted on the tower well to carry chain blocks.

A view of the vehicle interior, with the detachable panel of the tower-well removed, showing the tower structure in the lowered position, is reproduced herewith.

The vehicle underframe is constructed of steel channels and plates. The wheels are of rolled steel 2ft 6in diameter, and Hoffmann roller bearing axleboxes are employed. A Westinghouse straight air brake applies two blocks per wheel through rigging of the clasp brake type. The hand brake which is also fitted can be released or applied when necessary from outside the vehicle when the body doors are locked. The body is of steel construction, lined with timber to waist rail level, with the interior of the roof cork sprayed to guard against condensation.

INSPECTION VEHICLE WITH TOWER RAISED

The engine is a Gardner "4-LW" four cylinder unit developing 68 b.h.p. at 1700 r.p.m. Electric starting is provided; starting by hand is available in case of emergency. A traction type Vulcan-Sinclair hydraulic coupling is fitted to the engine flywheel. The change speed gearbox is a Wilson-Drewry 4-speed epicyclic unit, giving maximum speeds, in either direction of running, of 5·6, 9·8, 14·8 and 23·1 miles per hour; while, as previously mentioned, the vehicles can run at as low a speed as 1½ miles per hour when required. The reverse and reduction unit comprises bevel gears, with final drive by two Morse chains to sprockets on the driving axle.

The vehicle can be started from and driven from either end as may be convenient, means being provided for isolating the gear change and reverse controls at the non-operative end. The throttle is spring-loaded and incorporates a dead man's device, so that in the event of incapacity of the driver the throttle is released and an emergency brake application is made.

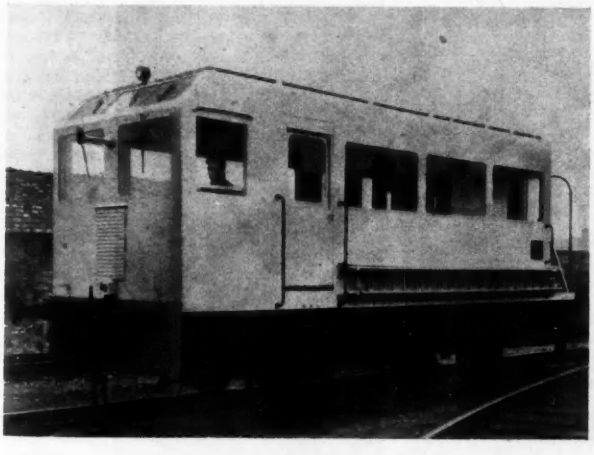
Gear changing and reversing are effected pneumatically, the controls being mechanically interlocked so that reversing can be effected only when the gear change control is in the neutral position. The driver's brake valve is self-lapping. A hand wheel for the screw brake is provided adjacent to each driving position.

A duplex air pressure gauge, engine oil pressure warning light, and engine oil pressure gauge are fitted. The control switch for the hydraulic pump clutch is placed on the control desk at the engine end only. Care has been taken to group the controls compactly for ease of driving, at the same time allowing the maximum of space for inspection personnel. A sliding seat with folding back rest is provided for the driver at each control position.

Two separate 24V electric circuits are provided, with a changeover switch to enable either battery to be connected to each circuit. One C.A.V. dynamo serves each circuit; the Exide batteries are each of 185 ampere hour capacity. Of the two circuits one covers control, interior lighting and engine starting, while the second takes care of outside lighting. An ammeter is provided in each circuit. The change-over switch, also the ammeters and fuses, are grouped on a panel above the battery container.

The elevating tower is of a two-stage telescopic structure, built of hardwood members suitably braced. The fixed platform, 8ft 0in long by 4ft 2in wide, has a minimum floor height of 11ft 8in and a maximum floor height of 19ft 0in from rail level. The platform is enclosed by handrails which fold inwards within the loading gauge when not in use. The elevating gear consists of a telescopic hydraulic ram oil pump and reservoir, solenoid operated control valve, with the necessary pipe-lines and push button switches mounted on the tower platform. Enclosed cable winders below floor level maintain tension on the 24V control cables and on the lighting cables to the sockets on the platform. A dog clutch (activated by diaphragm cylinders operated by electro-pneumatic valves through a switch mounted on the control desk at the engine end) controls the engagement and disengagement of the hydraulic pump.

The design of the vehicles was initiated under the supervision of the Chief Electrical Engineer, L.N.E.R., in conjunction with the Chief Mechanical Engineer, and has been completed under British Railways supervision.

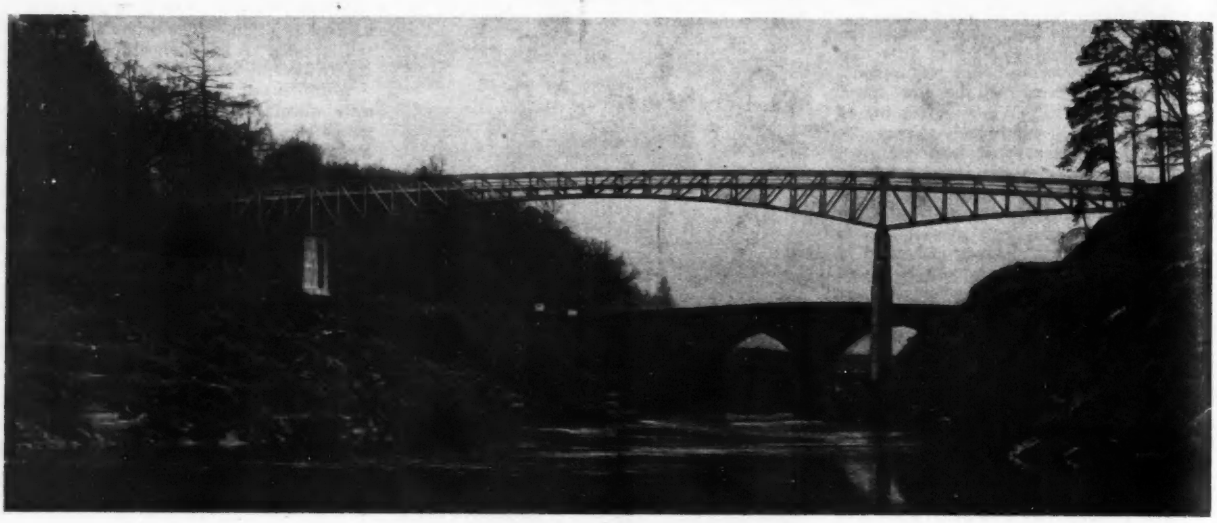


ENGINE END OF INSPECTION VEHICLE

VEHICLE INTERIOR WITH TOWER LOWERED

Aluminium Footbridge at Pitlochry

THE use of aluminium alloy as a structural material in bridge building is a comparatively recent trend, and there are as yet few examples of bridges constructed of aluminium. The first bridge incorporating aluminium to be built in this country was the bascule bridge at the port of Sunderland, which was completed in 1948 (see THE ENGINEER, December 3, 1948, page 575), and an arched aluminium highway bridge of 290ft span has recently been built at Arvida, in Canada (see THE ENGINEER, February 24, 1950, page 234).



ALUMINIUM FOOTBRIDGE, PITLOCHRY

In Scotland, this material has recently been used throughout in the construction of a pleasing footbridge near Pitlochry, which is illustrated herewith. The bridge is 310ft 6in long overall, with a centre span of 172ft 6in, and two side spans each of 69ft. It has been built for the North of Scotland Hydro-Electric Board as one of the ancillary works of the Tummel-Garry hydro-electric scheme, and replaces an old stone bridge (shown in our first illustration), which has been demolished as the level of the River Tummel has been raised by about 40ft at this point by the Pitlochry reservoir.

The roadway of the bridge follows the same curve as the top chord and is built up of aluminium sheeting with an asphaltic covering as may be seen from the cross sections on page 369. The bridge was designed for a loading of 84 lb per square foot over the entire footway, the aluminium sections being AW 10 B alloy (Services Schedule of Non-Ferrous Metals and Alloys BS/STA 7), the plates of AW 10 E, and the rivets of AW 6. The members marked "special section" in the diagram are joist sections provided with beading on the edges of the flanges to increase their lateral stability. A fixed bearing is provided at one of the piers, and at the other pier and the abutments there are expansion bearings of a conventional sliding groove design. The bridge has not been painted as it is thought that it will successfully resist atmospheric corrosion without such protection. Its behaviour under these conditions will provide some useful information in the future.

RIVETING PROBLEMS

Several interesting problems were encountered in the construction of the bridge, and since little information was available it was generally necessary to tackle them from first principles. Perhaps the problems of greatest engineering interest in connection with the bridge were those concerned with aluminium rivets. The contractors carried out a number of investigations to find out the most expeditious manner of riveting the bridge. Similar investigations have also been carried out in recent months for the erection of the Arvida Bridge, referred to above.* Considerable thought was given, before the bridge was detailed, to the question of using aluminium rivets or steel bolts coated with cadmium. It was agreed that the proper course was to use aluminium rivets if satisfactory heads could be formed. All the available information was read, but there was nothing final on which to decide. A series of experiments was therefore started to arrive at (1) possible types of rivet, (2) shape and size of heads of such rivets.

The bulk of the rivets for the bridge were made in the rivet-making shops of the contractors. As any type of head could be made on the rivet it was argued that the material itself would present no difficulty to the closing of that rivet. The trouble arose, it was found, in the method of closing.

Pieces of aluminium plate were procured from the makers for test purposes and these were drilled to certain clearances. The rivets used throughout were made from hot rolled and cold drawn rod, quality AW 6 D. This is a material (non-heat-treatable) which contains 4·5 to 5·5 per cent Mg, 0·15 per cent Cu, 0·75 per cent Fe, 0·6 per cent Si, 1 per cent Mn,

BRIDGE FROM NORTH BANK

* See *The Engineering Journal* (Journal of the Engineering Institute of Canada), June 1950.

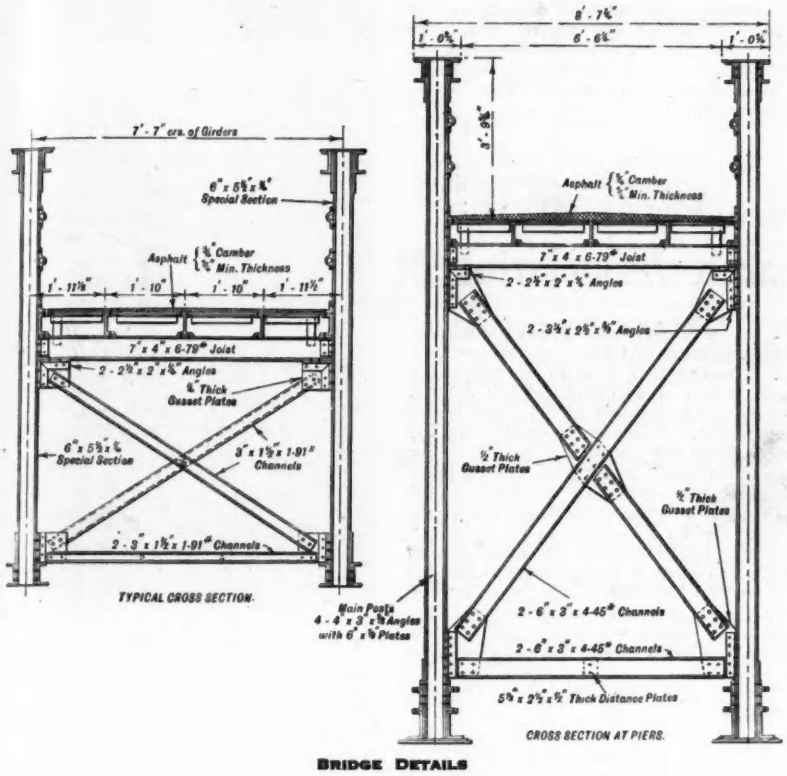
and 0·5 per cent Cr. The first attempts to drive experimental rivets ⅝in diameter cold were not successful. It was found that rivets, driven by pneumatic hammer fitted with the usual cup snap, work hardened before proper standard heads could be formed, and that the smaller hydraulic riveting machines were not heavy enough to close the rivets cold and form proper heads. There would have been no point in experimenting with large machines as most of the rivets on the bridge were inaccessible to these machines.

Heating was next tried. It was found that rivets heated to approximately 350 deg. Cent. could be driven quite successfully with a 20-ton hydraulic machine, and, when tested, sheared at a stress of 11·5 tons per square inch. As calculations were based on a working stress of 3½ tons per square inch, this was quite satisfactory. The difficulty was in controlling the temperature. Rivets slightly overheated were quite useless, and if there was any delay in driving too much heat was lost and the rivets would not close. This also applied to heated rivets closed by pneumatic hammer. The rivets cooled quickly owing to the low temperature and would not close properly. These difficulties might have been overcome for the shop rivets, but ruled out the use of heated rivets for site work.

It was then found that using a ⅛in snap and shorter rivets good heads could be formed by pneumatic hammer and the rivets filled the holes, giving a shearing strength of 13·4 tons per square inch when tested. These ⅛in heads had a very unsatisfactory appearance as such rivet groups at connections would have given an impression to the experienced eye that the joint connection was under-developed. A modified form of ⅝in snap was then tried, 1in diameter and $\frac{1}{16}$in high; this is the same diameter as the standard head, but ⅛in less in height. This gave very satisfactory results, good heads could be made either by pneumatic hammer or by a 30-ton hydraulic machine. Shear tests were made and it was found that the pneumatic rivets gave a shear stress of 13·7 tons per square inch and the hydraulic rivets a stress of 13·6 tons per square inch.

All the shear tests were made in single shear using two aluminium plates (AW 10 E) 2½in by ⅜in riveted together with two rivets at 2½in pitch and 1½in end distance. The rivets were exactly ⅝in diameter (there being practically no enlargement under the head), and the holes were drilled $\frac{11}{16}$in diameter. In all tests the rivets sheared; there were no indications of failure in bearing of the plates, as, after fracture, the rivets were slightly oval, but the holes remained circular.

Further trials with hydraulic rivets proved that the holes at the edge of the plates became enlarged, sometimes to a considerable extent.


7'-7" crs. of Girders
6" x 5⅝" x ⅝" Special Section
Asphalt ½" Camber ¼" Min. Thickness
1'-11½"
1'-10"
1'-10"
1'-11½"
7" x 4" x 6·79# Joist
2 - 2½" x 2" x ⅜" Angles
⅜" Thick Gusset Plates
6" x 5⅝" x ⅝" Special Section
3" x 1½" x 1·91# Channels
2 - 3" x 1½" x 1·91# Channels
TYPICAL CROSS SECTION
8'-7½"
1'-0½"
6'-6½"
1'-0½"
3'-0½"
Asphalt ½" Camber ¼" Min. Thickness
7" x 4" x 6·79# Joist
2 - 2½" x 2" x ⅜" Angles
2 - 3½" x 2½" x ⅝" Angles
½" Thick Gusset Plates
½" Thick Gusset Plates
2 - 6" x 3" x 4·45# Channels
2 - 6" x 3" x 4·45# Channels
5⅝" x 2½" x ½" Thick Distance Plates
Main Posts 4 - 4" x 3" x ⅜" Angles with 6" x ⅜" Plates
CROSS SECTION AT PIERS

Bridge Details

As practically all the material in the bridge was ⅛in thick and nearly all the holes were at plate or section edges, it was decided to abandon hydraulic rivets for this contract, as the consequences of these repeated enlargements would be bound to lead to distortions. Some doubt remained as to the efficiency of the modified rivet head in tension, and, although it was not considered in this instance a matter of great importance, tension rivet tests were carried out.

Of the tensile tests performed it is sufficient to quote four. The tests assemblies each consisted of two pieces of 5in by 4in ⅛in steel tees 3in long riveted together with two ⅝in diameter AW 6 D rivets at 2½in centres. The holes were $\frac{11}{16}$in diameter. The rivets were made with standard heads (1in by $\frac{7}{16}$in) and closed to the modified cup (1in by $\frac{1}{16}$in). Test pieces 1 and 2 were made with pneumatic rivets, and 3 and 4 with hydraulic rivets (30-ton machine). Steel tees were used to avoid any enlargement of the rivets after closing. The results obtained are shown below:

Test 1: Failed at 12·35 tons–18·2 tons per square inch tension; irregular fracture of one rivet in tension.

Test 2: Failed at 12 tons–17·7 tons per square inch; good conical fracture of one rivet in tension.

Test 3: Failed at 12·4 tons; one rivet sheared through modified head.

Test 4: Failed at 13·25 tons; both rivets sheared through modified head.

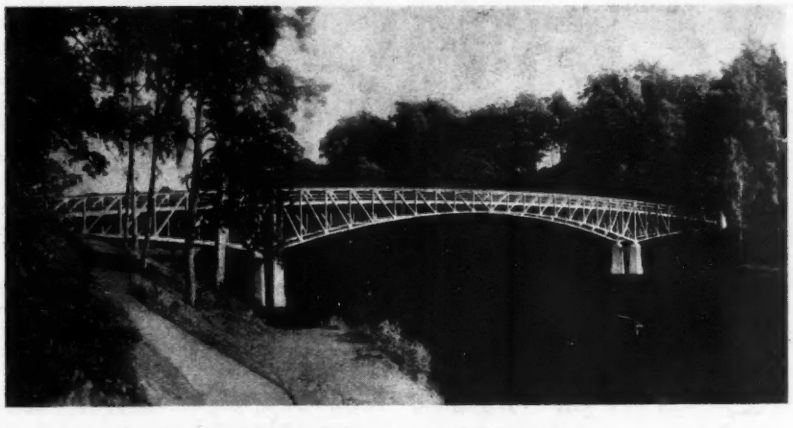
It will thus be seen that the modified heads in shear were stronger than the rivet shanks in tension for the pneumatic rivets, while the reverse was the case for the hydraulic rivets. The pneumatic rivets having stretched considerably in testing it was impossible to say whether they filled the holes completely or not, but from the value in tension of Test 1 it would appear that they did. The tests were considered satisfactory.

All the ⅝in diameter rivets on the bridge, both shop and site, were made with the modified head and driven cold by pneumatic hammer with the same size head. The driving technique was somewhat different to that used for driving hot steel rivets. A flat tool was first used, first in line with the rivet to stave it and fill the hole, then "rolled" until the head was nearly formed. A ⅛in deep concave snap was then used and "rolled" slightly to finish the head. It was found to be important to finish driving a rivet completely once it was started. All the riveting difficulties applied to the ⅝in diameter rivets; there were many ⅛in diameter rivets in the bridge deck and there was no difficulty in driving these with standard heads cold. However, heads about $\frac{1}{16}$in less than standard height were used, and it was found that considerable time could thus be saved. The pneumatic hammers used were Boyer "60" and Cleveland "50."

Erection

The materials were delivered to the site in panels 17ft 3in long except those on each side of the piers, which were delivered to suit road transport, and the centre panel. Unloading the lorries presented no difficulty as four men could lift a panel and carry it to wherever required. On the south bank the shore span passed over two roads, one leading to the men's hutted camp and the other to Pitlochry dam, and these roads had to be kept open to traffic. The north shore span was not over a road, but the river bank was very steep and uneven.

It was decided early in the contract to erect the shore spans (69ft long) a girder at a time, and, in order to lay these out for assembly, a gantry was built in tubular steel. This gantry also enabled the erectors to make the girders perfectly flat before riveting. These girders weighed approximately 32 cwt when riveted, and to erect them a 2-ton derrick was used. Immediately the two girders at each end were



Bridge with Reservoir Filled

erected the diagonal bracing, flooring beams and floor plates were erected and securely bolted.

From the piers to the centre the main span was built out in panels from each end, all joints being riveted and all bracings and floor plates placed before the next panel was added. This method gave the erectors a good sound footing for carrying the panels along to the point of erection, as well as stiffening the structure. Before the centre panel was placed in position, about 2 tons of ballast was placed on the shore spans. This had the effect of keeping the "nose" up. The bottom chords of the centre panel were placed in position, and struts, ties and top chords completed. The ballast was then removed after riveting had been completed. Finally, the anchor bolts at the abutments were loosened and the bridge came up to the level of the pathway at both ends. Expansion bearings were packed up to the underside of the bridge and the cover plate between the abutment and the bridge was riveted. During erection a 10 cwt short-legged hand crane was found very useful for reaching out to place the panels.

The consulting engineers for the aluminium bridge were Sir Alexander Gibb and Partners, and the contractors were P. and W. McLellan, Ltd., Glasgow. The aluminium material was supplied by James Booth and Co., Ltd. The concrete piers, which were specially designed on slender lines to be in keeping with the bridge structure, were constructed by Wm. Tawse, Ltd., Aberdeen.

Pulsating Pressure Test Plant of the British Welding Research Association

RECENTLY we were present at the laboratories of the British Welding Research Association, at Abington Hall, near Cambridge, when a new pulsating pressure plant was inaugurated and demonstrated. This plant, said to be the first of its kind in the country is to be used for the fatigue testing of pressure vessels and it will be a valuable addition to the facilities of the laboratory in the research work being carried out in connection with welded pressure vessels and pipelines. With this plant vessels can be tested by repeated applications of internal pressures between any two specified limits up to a maximum of 6000 lb per square inch. In the case of vessels of moderate size, the pressure cycle can be repeated up to 100 times a minute. A particular advantage that a pulsating pressure test has over the commonly used static pressure test is that vessels which will be subjected to varying pressures in service can be tested under similar conditions during their initial development. The information obtained from tests with the new plant will, it is anticipated, make it possible to establish the relationship between material properties, service stress and the life expectation of pressure vessels in service.

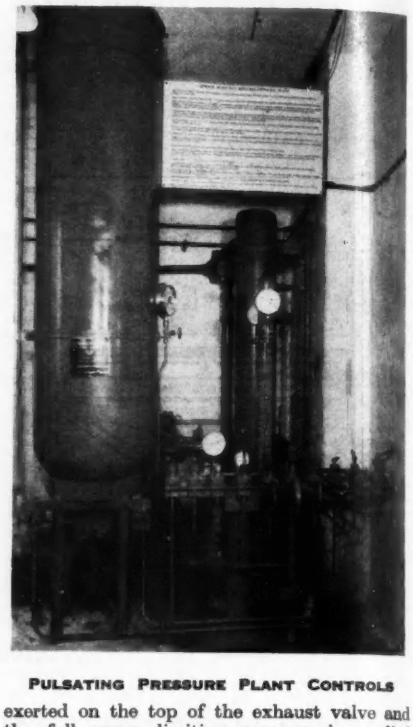
The new plant was built for the association by Werner and Pfleiderer, of Stuttgart, and on this page we reproduce two photographs and a diagram showing its operation. The hydraulic fluid for testing is supplied by a three-ram pump driven by a 75 h.p. motor, and it is designed to deliver 12 gallons per minute against a pressure of 6000 lb per square inch to the vessel being tested. A smaller pump with a capacity of 1 gallon per minute, against a pressure of 6000 lb per square inch, works in conjunction with an air compressor with an intake of 40 cubic feet per minute, to supply air and water to the plant before testing begins. This smaller pump and the air compressor set the desired conditions for testing in a vessel containing fluid at the lower pressure required for testing, in a second vessel containing fluid at the upper pressure required for testing and an accumulator.

Referring to the diagram, the main exhaust valve, which controls the pressure pulsations in the vessel under test, is controlled by the movement of a piston in a servo cylinder. One end of this cylinder is connected to the test vessel and the other end to the upper pressure limit vessel. The piston moves along the cylinder when the pressure difference on its front and rear ends is 1–1½ per cent.

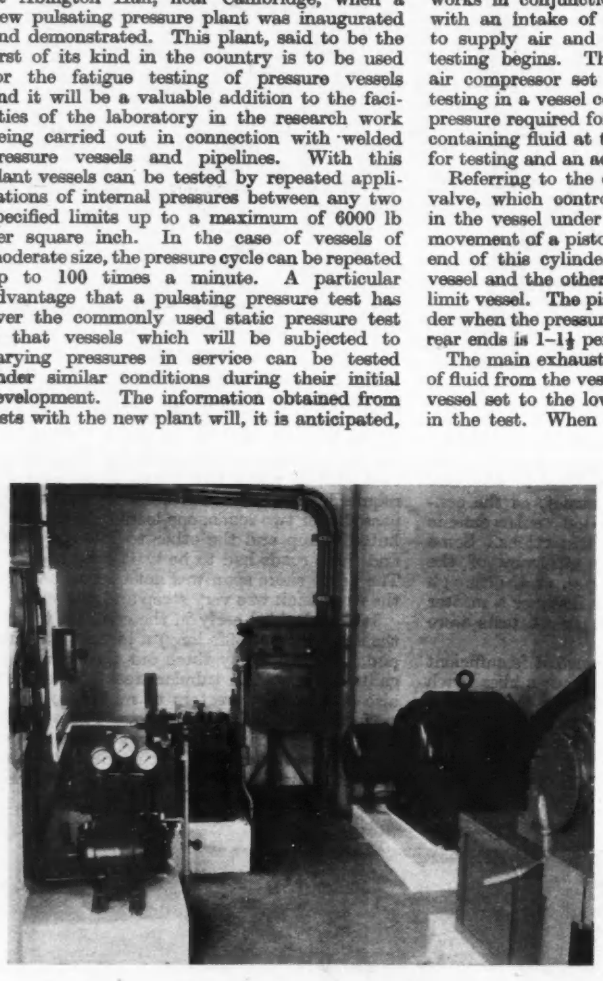
The main exhaust valve controls the passage of fluid from the vessel under test and the large vessel set to the lower pressure limit required in the test. When the valve is open the two vessels are connected and the pressure in them is equalised. When the valve is closed the main pump draws fluid from the low pressure limit vessel and forces it into the test vessel; at the same time fluid at the same pressure is forced into one end of the servo cylinder. When this pressure is 1½ per cent greater than that exerted on the opposite side of the piston in the servo cylinder by the fluid in the upper pressure limit vessel, the piston moves along the cylinder. It will be seen that the piston rod actuates a lever, which controls the operation of two servo valves. The arrangement being such that when one servo valve is opened the other is closed.

In the cycle of operations when the test vessel has been pumped to its upper pressure limit and the servo piston has travelled along the cylinder to open the upper servo valve, fluid can flow directly from the top of the main exhaust valve to the suction side of the pump. As at this stage there is very little pressure exerted on the top of the exhaust valve and the full upper limiting pressure is applied below it, the valve is forced open. Directly the valve is opened fluid flows from the vessel under test into the lower pressure limit vessel and the pressures in the two vessels are equalised. At the same time the pressure on one side of the servo piston drops to this lower limit and the piston travels back, its rod linkage closing the upper servo valve and opening the lower one. Fluid under pressure from the accumulator thereupon flows through the servo valve to the top of the exhaust valve, which is closed by the greater pressure and the pumping-up cycle recommences.

In one of the photographs reproduced on this page can be seen the controlling valves of the test plant with the lower and upper pressure limit vessels and the accumulator. In the other photograph showing the pump



PULSATING PRESSURE PLANT CONTROLS



TEST PLANT PUMP ROOM

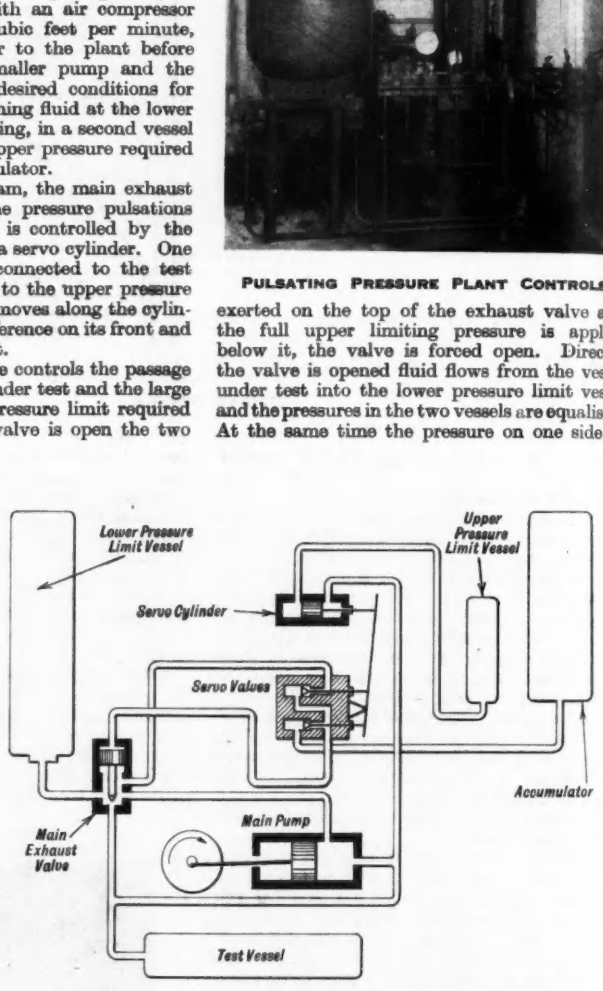


DIAGRAM OF PULSATING PRESSURE CONTROLS

room the main pump is on the right and the small pump and air compressor are on the left hand side.

Whilst we were at this research establishment we were informed that plans are now in hand for the erection of a new permanent laboratory, which will be used primarily for the association's research programme on the fatigue strength of welded structures. Up to now investigations have been carried out by the resonance method in temporary huts and the new building, in addition to considerably increased facilities, will provide twice the floor area of the present accommodation. For this work a 100-ton Losenhausen fatigue machine has been ordered and the equipment to be installed includes a 5-ton crane for handling heavy specimens.

Locomotives for South African Railways

(By our South African Correspondent)

A LARGE number of locomotives of the older classes on South African railways are to be replaced by locomotives better suited to present-day requirements. Due to their light axle loading, these older locomotives have been employed on light branch lines and on extensive sections of the South-West Africa main lines, where light section rails and comparatively light track structures preclude the use of heavier classes of engines. In providing for this replacement it has, therefore, been necessary to make available locomotives suitable for operating on track laid with 45 lb rails (the standard rail employed on the S.A.R. Administration's Class I main line track weighs 96 lb). All the new locomotives have been built by the North British Locomotive Company and erected at the Administration's workshops at Uitenhage.

These locomotives represent a departure in South African Railways' locomotive design in that they are provided with cast steel main frames, each frame being cast integrally with the cylinders, hind cylinder covers, smokebox support frame stays and various brackets supporting the boiler, motion gear and brake gear. On the plate frames and bar frames hitherto employed, these fittings are bolted or riveted to the frames, and the forces resulting from the reaction of the cylinders, thermal expansion and unevenness of the track tend to cause the frame members to creep or work loose, thus stretching or loosening the bolts or rivets holding the various parts, and leading to heavy maintenance costs. On the integrally cast frames no relative movement is possible whilst the number of bolted or riveted fittings has been reduced to the minimum, and it is confidently expected that this innovation will result in reduced maintenance and in increased utilisation of engine power. A further advantage of the cast steel frame is that a considerable saving in weight is effected.

The boiler is of the standard S.A.R. No. 1 design, but is provided with arch tubes in the firebox, and is fitted with an inner firebox of composite construction, the tube plate being of steel, and the wrapper plate and inner back plate of copper. This construction is adopted to provide greater resistance to corrosive attack by the poor quality boiler water used, particularly in South-West Africa. The rigid firebox stays outside the breaking zones are of copper, whilst the flexible stays in the breaking zones are of steel to standard S.A.R. design. The distance between tube plates is 17ft 9in, and there are seventy-six small tubes of 2½in external diameter, and twenty-four superheater flue tubes of 5½in external diameter. A standard superheater incorporating a multiple-valve regulator is fitted in the smokebox, and standard type boiler mountings including steam turret, safety valves, blow-off cocks, injectors and hydrostatic lubricators are provided.

The wheel arrangement adopted is a reversal of the normal 4–8–2 arrangement, the two-wheeled truck having in this case been placed at the front and the four-wheeled bogie at the rear to carry the comparatively heavy weight at the firebox end of the boiler. The frames of both the leading truck and the trailing bogie are steel castings and are provided with constant resistance centring devices of the rocker type, whilst roller bearings are fitted to the axles of the truck and bogie wheels. The spring suspension is designed to provide compensation of the loads on all the axles of the locomotive, the compensating gear being arranged in two groups with the leading truck and the leading and intermediate coupled axles forming the front group, whilst the driving and trailing coupled axles with the trailing bogie axles form the hind group. The coupled wheels are 4ft 3in diameter. The cylinders are 19in diameter by 26in stroke with 10in diameter piston valves actuated by Walschaerts valve gear, both the cylinders and the steam chests being provided with renewable cast iron liners. All the coupled wheels are fitted with flanged tyres to the standard S.A.R. profile, and vacuum-operated brake gear, acting on the first three pairs of coupled wheels only, is fitted.

Since these locomotives will to a large extent operate over sections where water supplies are scarce and unreliable, the tender has been designed to accommodate the maximum amount of water compatible with track limitations. These tenders are therefore arranged to carry 9 tons of coal and 4500 gallons of water, this water capacity being 50 per cent greater than that provided on the tenders of the older class engines. The tender tanks are of cylindrica construction without internal stays or baffles, and are rigidly attached to the underframe at the front end only, the rear end being held down by means of adjustable steel straps attached to the underframe and passing round the body of the tank. This method of support permits a certain degree of freedom of movement and allows the comparatively flexible underframe to adjust itself to unevenness in the track without being constrained by the inherently rigid structure of the tank. The weight of water carried in conjunction with the restricted axle loading has necessitated the provision of six-wheeled tender bogies, these being of the Buckeye type built up of steel castings and compensated to distribute the load equally over the axles in each bogie.

The principal dimensions of the locomotives are as follows :—Cylinders, 19in diameter by 26in stroke ; coupled wheels, 4ft 3in diameter ; truck and bogie wheels, 2ft 6in diameter ; total wheelbase, 31ft ; coupled wheelbase, 13rt 6in ; heating surface, tubes 1497 square feet, arch tubes, 16 square feet ; firebox, 123 square feet ; total, 1636 square feet ; superheater area, 380 square feet ; grate area, 36 square feet ; boiler pressure, 200 lb per square inch ; tractive force (75 per cent b.p.), 27,600 lb ; weight in working order, 72 tons 18 cwt ; adhesion factor, 3·66.

It is interesting to compare these locomotives with those of classes " 8W–8FW," which they are to replace, for whilst the tractive force has been increased by only about 2 per cent, the boiler heating surface has been increased by 50 per cent, the superheater area by 30 per cent, and the grate area by 70 per cent. These changes make for better combustion of the fuel and greater steaming capacity the results being reflected in higher sustained speeds and reduced running times. This is borne out by the fact that although the classes " 8W–8FW " and the new class " 24 " engines exert about the same drawbar pull at starting, the latter class of locomotive develops about 50 per cent more power at a speed of 30 m.p.h. than do the classes " 8W–8FW." As is to be expected, this increase in boiler capacity has been attained at the expense of an increase of about 12 tons in the total weight of the locomotive, but, by careful design and attention to detail this total weight has been so distributed over the various axles that it has been possible to reduce the maximum individual axle loading to a figure below that of the classes "8F–8FW " engines. On the latter class of engines the average coupled-wheel axle load is 12 tons 1 cwt, whereas on the class " 24 " engines the average coupled-wheel axle load is 11 tons 6 cwt, this result having been achieved by the provision of an additional carrying axle and an increase in the loads carried by the bogies, thus providing more even loading of the track. In addition, the hammer blow exerted on the rails by the out-of-balance forces on the coupled wheels has been limited to a maximum value of 15 cwt at a speed of 40 m.p.h., thereby further reducing the stresses developed in the track.

Before releasing the first locomotive of this class for general service, it was subjected to a series of road tests, the primary object being to establish whether the draughting arrangements provided were satisfactory and whether the boiler steamed freely. Four test series were made with various train loads, the dynamometer car being attached immediately behind the tender for the purpose of providing data regarding drawbar pull speed, time, distance, &c. The engine and boiler performances proved to be highly satisfactory and at the very high power outputs the locomotive was able to maintain a high steam pressure, whilst at the same time keeping the water in the boiler at a safe level. During one test, a load of 310 tons for forty axles was taken from Port Elizabeth to Klipplaat, a section on which there are long gradients of 1 in 40, and the maximum horsepower developed at the coupled wheels was in excess of 1600 h.p. This load is considered to be the maximum that this class of locomotive will be able to haul over this section, having regard to the timings aliowed, and agrees very well with the theoretical loads calculated before the tests were carried out. It was found after the tests that very little char had collected in the smokebox, which indicates that the spark arrester possesses satisfactory self-cleaning characteristics. During the tests the locomotive proved to be light in coal and water consumption, and was found to ride more comfortably at all speeds than is generally the case with other classes of engines. No longitudinal shocks or oscillations were noticed, and the lateral shocks felt when entering or leaving curves or points were very slight in comparison with those normally experienced.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1.

PRECAST CONCRETE KERBS, CHANNELS, EDGINGS AND QUADRANTS

No. 340 : 1950. This revision has been prepared to cover a modified range of sections which, it is thought, will be adequate to cover the needs of users in various parts of the country. The standard includes tests and limits for transverse strength and water absorption. The tests are intended to serve as indirect methods of assessing the resistance of the kerbs to frost and impact, as it is not yet possible to apply direct tests for these qualities. The new edition makes a departure from previous editions in that the load in the transverse strength tests varies according to the age of the sample, so that results carried out at different ages can be compared. The test for water absorption has been modified with a view to obtaining consistency of results when tests are carried out at different laboratories. Price 2s. 6d. post free.

FLANGED AUTOMATIC CONTROL VALVES (FACE-TO-FACE DIMENSIONS)

No. 1655 : 1950. This standard has been devised primarily to cover the face-to-face dimensions of automatic control valves of the conventional pneumatic diaphragm operated single or double-beat type, with a recommendation that other control valves should also comply with the standard. The standard includes tables giving the dimensions for two categories of valves equipped with flanges to one of the four following British Standards :—

B.S. 10 : Tables of Pipe Flanges (for Land Use).

B.S. 1560 : Steel Pipe Flanges and Flanged Fittings for the Petroleum Industry.

B.S. 1575 : Cast Iron Pipe Flanges and Flanged Fittings, Class 125, for the Petroleum Industry.

B.S. 1576 : Cast Iron Pipe Flanges and Flanged Fittings, Class 250, for the Petroleum Industry Price 2s. 6d. post free.

British Patent Specifications

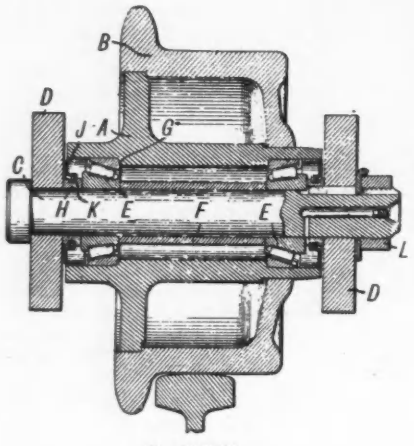
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

RAILWAY ENGINEERING

641,306. February 28, 1948.—IMPROVEMENTS IN OR RELATING TO WHEEL ASSEMBLIES, Henry Fort Flowers, of Findlay, County of Hancock, Ohio, U.S.A.

The invention concerns railway truck wheels, in particular the small diameter flanged wheels used in mine cars and the like. Its objects are to provide a wheel structure in which the best suitable materials, processes and heat-treatments may be selected for the component parts, using a hard, abrasion-resisting steel in a replaceable rim and a free-machining steel in the wheel centre; to provide a wheel so constructed that new tread and flange wearing surfaces may be provided on a worn wheel without the necessity of re-machining the hub of the wheel to install anti-friction bearings; and to provide a wheel of two simple component parts,



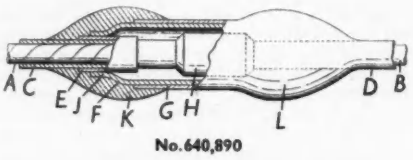
No. 641,306

both of which can be economically forged from standard steel billets on high-production forging presses. As shown in the drawing, a typical wheel assembly consists of a webbed wheel centre *A*, on which is fitted a webbed wheel rim *B*. The webbed wheel centre, which is machined on the interior to provide proper seats for anti-friction bearings, is mounted on a spindle *C*, which in turn is mounted in the side frames *D* of the truck. Between the webbed wheel centre and the spindle *C* are bearings *E* of the usual type. These bearings are held in position by a spacing sleeve *F* and by shoulders *G* formed on the inner surface of the webbed wheel centre. Between the bearings and the side frames of the truck are outer spacing sleeves *H*, dust seals *J* and snap ring oil seals *K*. The entire assembly is clamped in place by threading nut *L* on the end of spindle *C*. The specific mounting of the webbed wheel centre on the spindle or stub axle of an axleless truck forms no part of the present invention, but is shown, described and claimed in the prior Specification No. 603,951. In the present specification the manufacture, machining, assembly and fitting of new treads is described.—*August* 9, 1950.

ELECTRICAL ENGINEERING

640,890. December 7, 1948.—AN IMPROVED JOINT FOR ELECTRIC CABLES, British Insulated Callender's Cables, Ltd., of Norfolk House, Norfolk Street, London, W.C.2, and Cyril Cuttell Howis, of Howards Farm, Eccleston, St. Helens, Lancashire.

This invention relates to the making of a joint between two lengths of electric cable of which the outer covering is of polyethylene or has polyethylene as its principal constituent. The accompanying drawing shows an elevation, partly in cross section, of the completed joint. It is made between two lengths of cable *A* and *B*, having outer coverings *C* and D of polyethylene. Before making the joint between the conductors of the two cable lengths, a sleeve, such as *E*, of polyethylene, which fits closely on to the outer covering, is slipped over the end of each cable length. A lead tube *F*, provided with a tubular covering *G* of polyethylene, extending over the whole of its outer surface except for a strip at either end, is then slipped over the end of one of the cable lengths. The joint between the conductors is now made and provided with insulation *H* in the normal way. The lead sleeve *F* is now moved into position over the conductor joint and it is dressed down at each end, as at *J*, to fit over the polyethylene sleeves *E* which protect the cables from injury during this process. A body of polyethylene is now built up on one side of the joint by pouring molten polyethylene over one end of the lead tube *F*, and the exposed part of the sleeve *E*, beginning adjacent to the cable covering *C* and working along the exposed part of the lead tube *F* until a complete enclosure *K* from the cable covering



No. 640,890

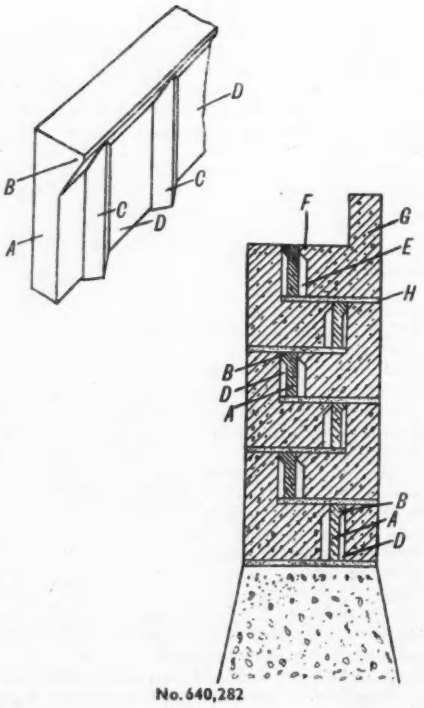
C to the polyethylene covering *G* has been provided.

In this process the polyethylene is kneaded and moulded into place by means of a suitable tool, such as a broad-bladed, rigid spatula, the polyethylene being kept in a soft sticky condition by the occasional application to it of heat, as by the flame of a lamp, so as to be mouldable. Since the main object is to obtain continuity of the polyethylene covering, it is important to ensure integral connection between the added material and the cable covering *C* and between the added material and the tubular polyethylene covering *G*. To ensure such continuity, it is advantageous to warm the coverings *C* and *G* before commencing to build up the polyethylene body. The process is then repeated on the opposite side of the joint and a similar enclosure *L* is formed in the same way.—*August* 2, 1950.

STRUCTURAL ENGINEERING

640,282. August 12, 1947.—IMPROVEMENTS IN OR RELATING TO BUILDING MEMBERS, Aktiebolaget Ell-Block, of 12, Kyrkogatan, Jönköping, Sweden (*assignees of Karl Harald Brandtlofkvist, of Box 95, Ekenässjön, Sweden*).

The present invention concerns building members in the form of stones or blocks of particular shape. An object of the invention is to provide an improved



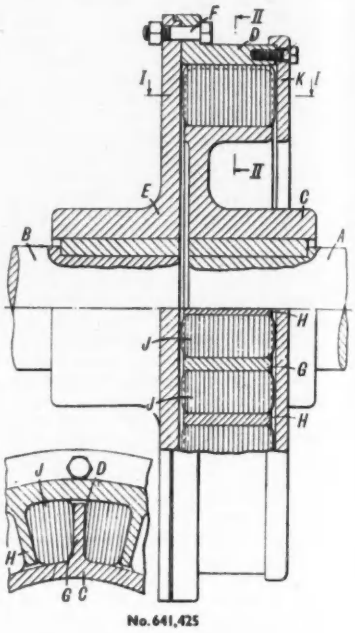
No. 640,282

type of building member by means of which heat insulating air spaces are formed in wall constructions. In the accompanying drawings a spacing block *A* has a projection or rib *B* running lengthwise near its upper edge. The block is also provided with ribs *C* running at an angle, preferably at right angles to the projection *B* and suitably extending a short distance past the lower edge of the block in order to provide anchorage in a mortar joint or layer *H* on top of the lower stone on which it rests. Air spaces D are formed by the projections on the spacing block. Other similar air spaces *E* are formed by means of projections or ribs *F* on L-blocks *G*, which ribs abut against that side of the spacing blocks *A*, which has no projection. The building system using spacing means of the kind described can thus be provided not only with heat-insulating bodies, but with numerous closed air spaces *D* or *E* respectively which, by means of the ribs, will form a closed heat-insulating cell system in which air and moisture are prevented from circulating; thus the insulating effect is considerably enhanced.—*July* 19, 1950.

MISCELLANEOUS

641,425. April 1, 1947.—IMPROVEMENTS IN OR RELATING TO FLEXIBLE COUPLINGS, DAMPERS AND THE LIKE, Louis Paul Croset, of 97, Shrub End Road, Colchester, Essex.

The object of this invention is to provide an improved construction, particularly in the case of



No. 641,425

the arms and elastic members, giving increased elasticity and reliability, whilst at the same time economising in material and manufacturing time and offering a wider scope of application than hitherto available. In the accompanying drawings with sections on I–I and II–II, a coupling is shown made in accordance with the invention. *A* and *B* are driving and driven shafts respectively which carry concentric coupling driving and driven members *C* and *D* respectively, the latter being connected to the shaft *B* by means of a disc *E* and bolts *F*. The members are provided on their outer and inner periphery respectively with substantially flat radial blades or plates *G* and *H*. The members *C* and *D* are in the form of drums or cylinders and one is located within and spaced from the other. The blades on the outer drum extend inwardly and alternate with the outwardly extending blades on the inner drum. The blades are of constant thickness and a clearance is provided between their free ends and the concentric members. Between each pair of adjacent blades is a resilient force-transmitting element or block *J* which is of wedge form or generally tapering radially with its smaller ends innermost and made of natural rubber or synthetic rubber-like material. The blocks are of wedge shape in end view and rectangular in longitudinal section and in contact with the outer concentric member over their whole circumferential width and their whole length. Each of the blocks is symmetrical about a central radial plane. These elements are suitably pre-compressed or pre-loaded and held against excessive axial displacement on one side by the disc *E* and on the other by a retaining plate *K*, or ring of annular form, removable for insertion, inspection or removal of the blocks *J*. The disc and plate limit the deformation of the blocks to a pre-determined value which is slightly less than that of the pre-loading in order to prevent complete unloading even under the most severe torque fluctuations.—*August* 9, 1950.

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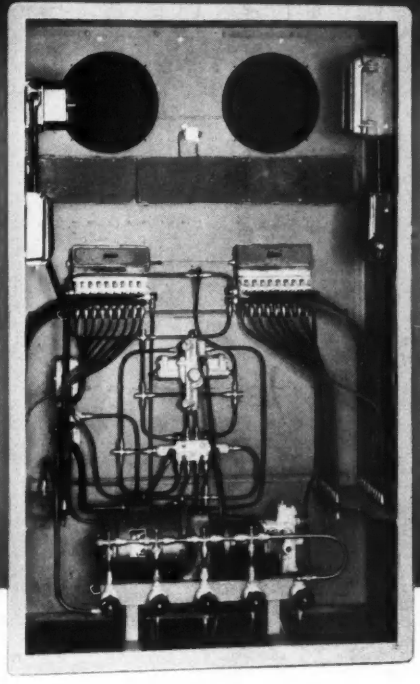

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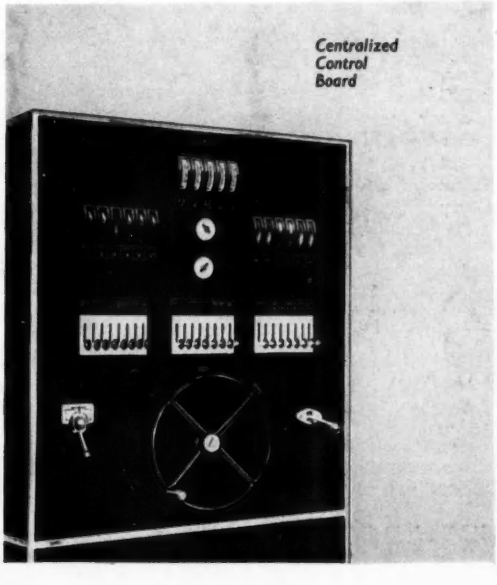

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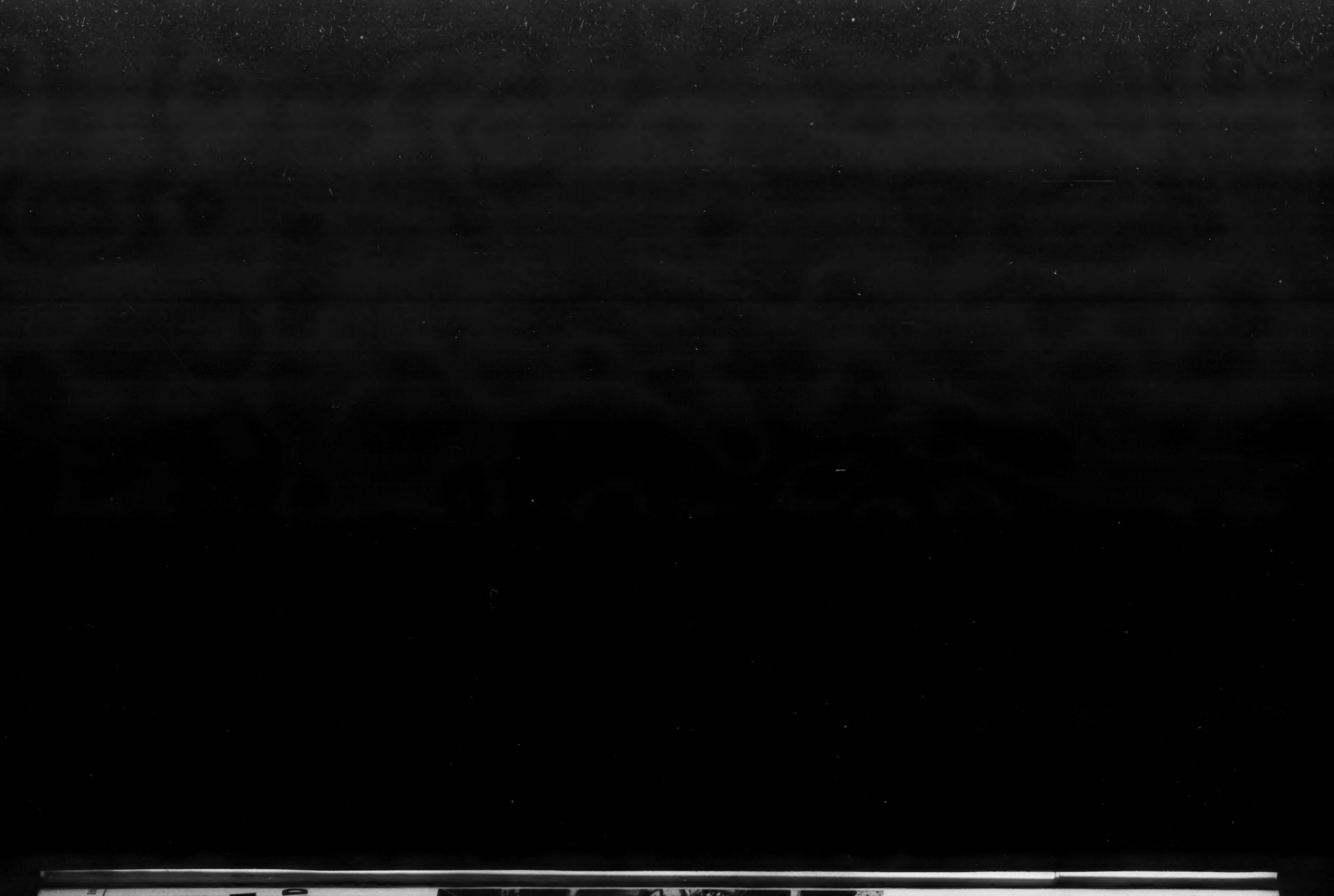
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